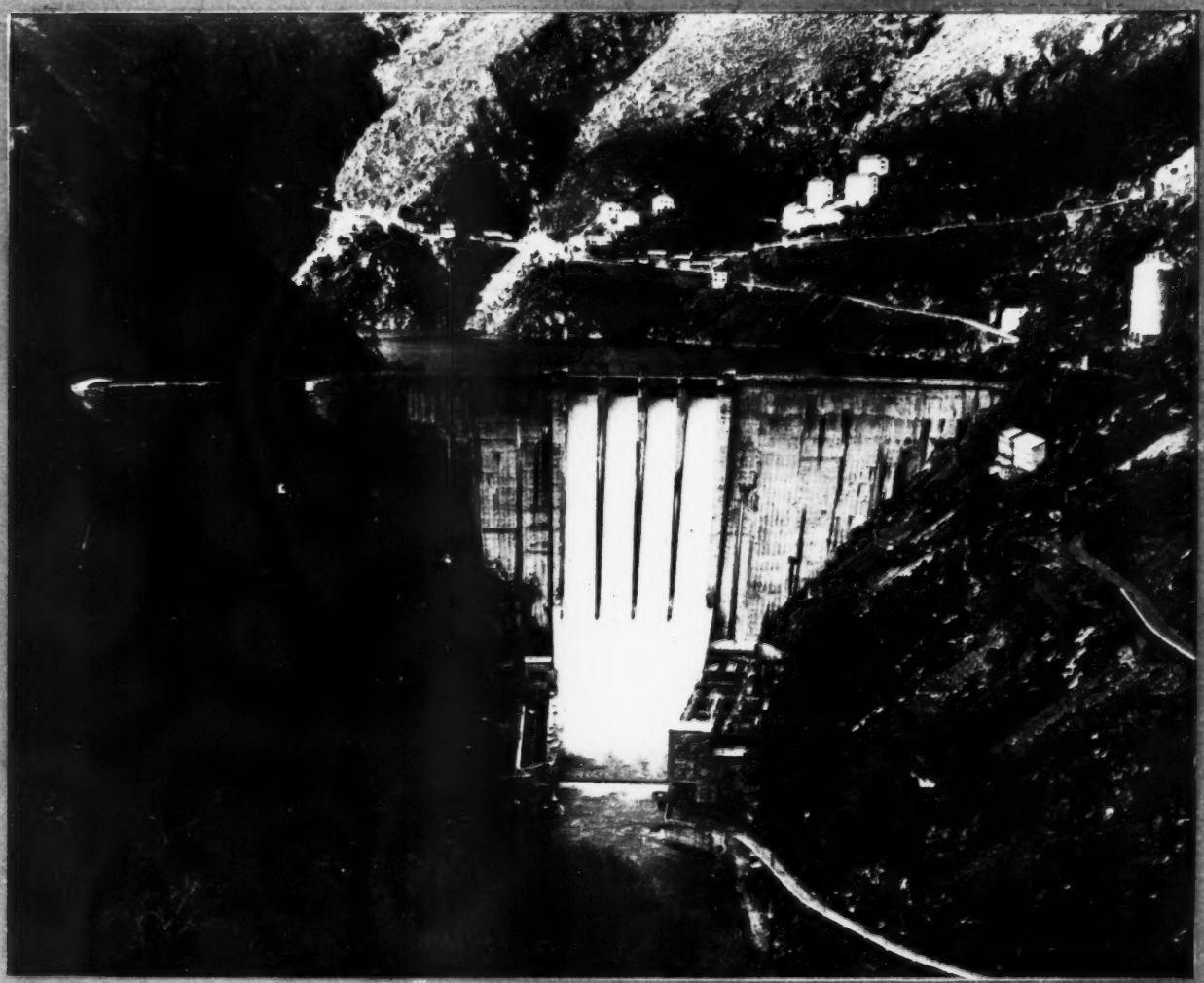
T2
163

# INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

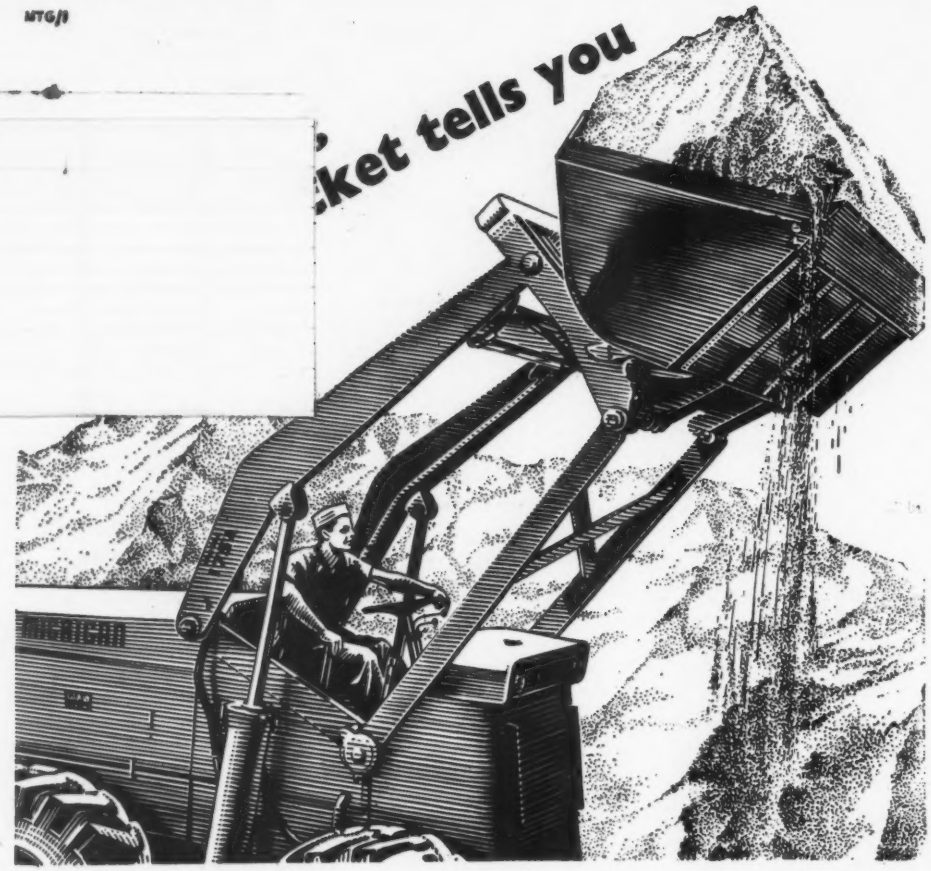
THE JOHN CHERAR LIBRARY
JUL 30 1957

VOL. VII. NO. 3 MARCH 1957 RUPEES TWO



THE DAM & SPILLWAY FOR THE SALIME HYDRO-ELECTRIC POWER STATION, SPAIN.

MTG/1




*It's a*

# MICHIGAN

## *TRACTOR SHOVEL*

*A complete range of sizes (15 cu. ft. to 2¼ cu. yds.) for Construction, Industrial, Municipalities, Quarries, Mining, Logging and Foundry applications.*

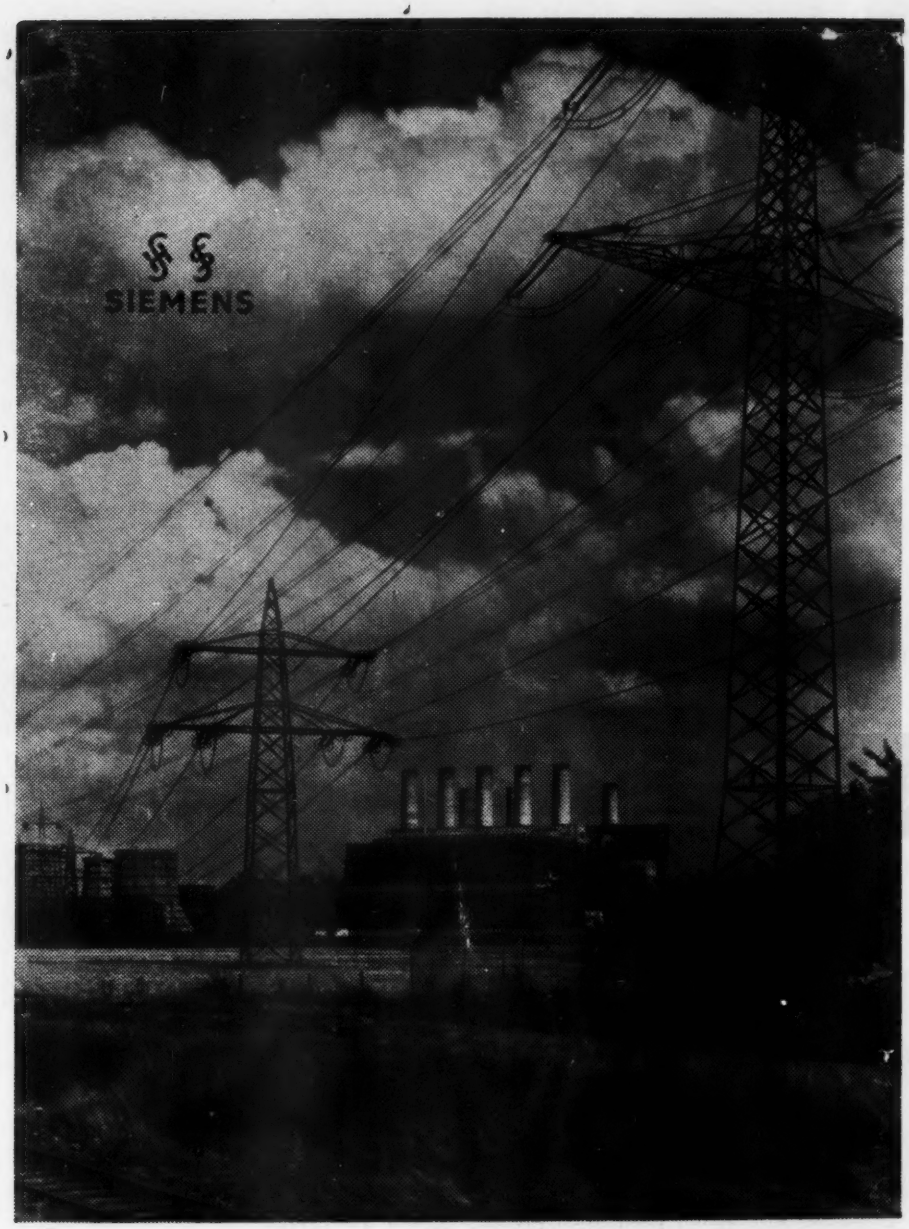
**BLACKWOOD HODGE**

BH BLACKWOOD HODGE

BLACKWOOD HODGE (INDIA) PRIVATE LTD.

CALCUTTA • MADRAS • DELHI • BOMBAY

Associated Companies Branches Works and Agencies Throughout the World.




SIEMENS & HALSKE AG - SIEMENS SCHUCKERTWERKE AG
WESTERN GERMANY

*SOLE REPRESENTATIVES:*

**SIEMENS ENGINEERING & MANUFACTURING CO. OF INDIA PRIVATE LTD.**

BOMBAY - CALCUTTA - NEW DELHI

**P&H**

# EXCAVATORS
## built for the toughest digging

### *with Magnetorque Electric Swing!*

For the most punishing power shovel work—digging and loading rock—the P & H Model 955-A sets new records for speed and stamina. An outstanding example of advanced engineering, this excavator is equipped with the Magnetorque swing, which eliminates troublesome friction clutches—produces 20% faster—lasts the life of the machine. The P & H Model 955-A is a sound investment for big construction jobs, open pit mining and quarrying.

*Manufactured by* **HARNISCHFEGER CORPORATION** U.S.A.

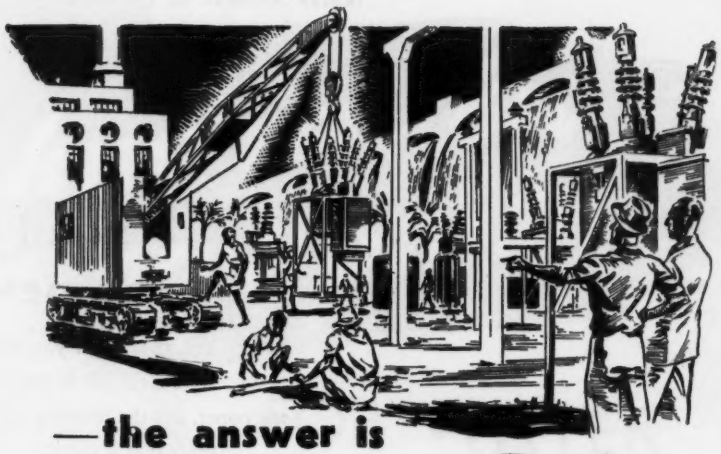
*Sole Distributors:*

**VOLTAS**

**VOLTAS LIMITED**

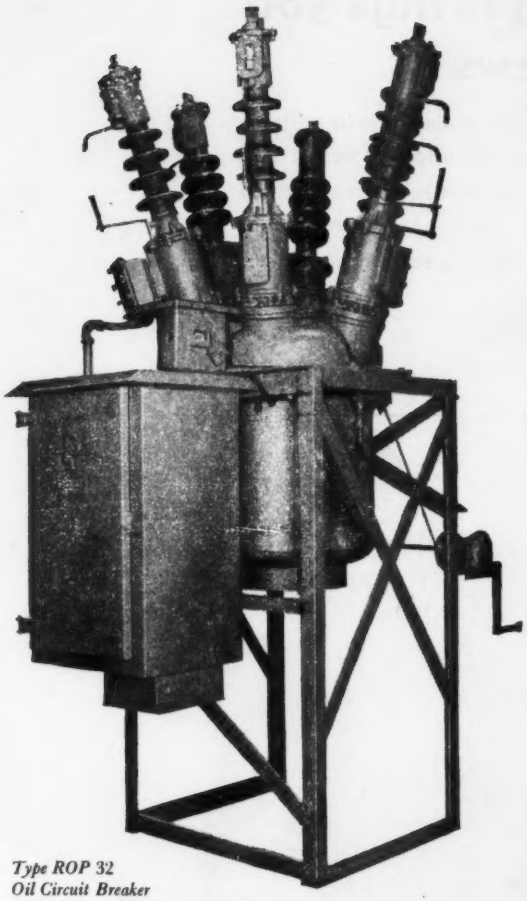
Bombay - Calcutta - Madras - New Delhi - Cochin - Bangalore - Lucknow - Ahmedabad - Secunderabad

# When the call is for SWITCHGEAR—



—the answer is

*Ferguson Pailin*



*Type ROP 32*
*Oil Circuit Breaker*

When the dam is built and the major constructional work completed the task of installing the electrical plant and the equipment must be undertaken.

Ferguson Pailin have supplied switchgear for indoor and outdoor stations, including major hydro-electric schemes the world over. 'F. P.' is synonymous with first-class design, manufacture and performance of this essential equipment, ranging from extra high voltage switchgear for main grid supply systems down to low voltage switchgear for industrial purposes.

*Two examples of 'Ferguson Pailin' switchgear, for varying duties, are illustrated here. They are :—*

**ROP 32 OIL CIRCUIT-BREAKER**

Wherever 22 kV or 33 kV outdoor oil circuit-breakers for breaking capacities up to 750 MVA are required the merits of the 'ROP 32' breaker should be considered.

The design of this breaker provides for the optimum protection against adverse working conditions peculiar to countries in various parts of the world as well as maximum resistance to the effects of fluctuating temperatures and humidity.

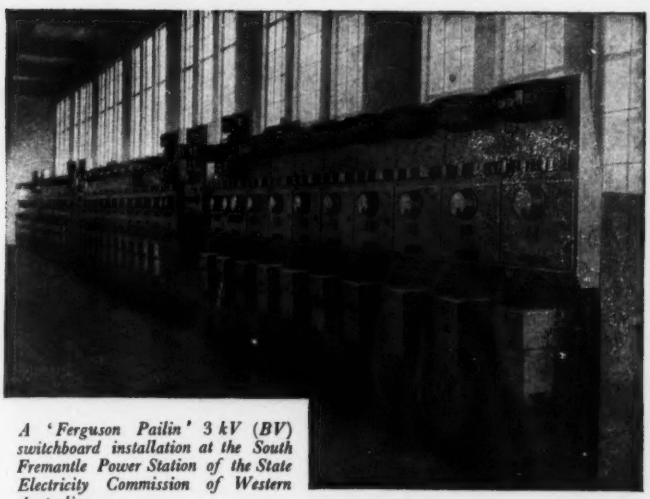
The versatility of the 'ROP 32' makes it remarkably adaptable to local requirements. Complete dependability and reliability make it a natural choice for incorporation into any scheme involving the transmission of power at 22 kV or 33 kV.

The circuit-breaker tank is of cylindrical shape and all three phases are brought into one tank, permitting the use of smaller framework thereby achieving compactness.

**'BV' SWITCHGEAR**

'Ferguson Pailin' Type BV switchgear is of the completely enclosed metalclad type. It is constructed on the unit principle and can readily be extended by units of similar rating, or by metalclad oil switches.

Vertical isolation of the breaker ensures minimum space requirements of the unit, whilst adequate interlocks safeguard against mal-operation.



*A 'Ferguson Pailin' 3 kV (BV) switchboard installation at the South Fremantle Power Station of the State Electricity Commission of Western Australia.*

**Ferguson Pailin** LIMITED — *for Switchgear*

Member of the A.E.I. Group of Companies

Head Office & Works: HR. OPENSHAW MANCHESTER 11. ENGLAND

*Represented in India and Pakistan by*

A. E. I. (India) Private Ltd., Head Office : Crown House, 6, Mission Row, Calcutta, P. O. Box 271.
A. E. I. (Pakistan) Ltd., Head Office : Bombay Company Building, Wallace Road, Karachi, P. O. Box 746.

# steel brings you the news

Yes, that paper you are reading owes its existence to steel. It is steel that helped to manufacture the paper, did the printing and even helped to collect the news that it carries. There is hardly any facet of life where steel does not play a part in one way or another.

**TATA STEEL**

SERVES THE NATION

*Steel, today, is very much to the fore in the nation's thinking. India's steel-making capacity is being rapidly enlarged to provide a sure and solid basis for the country's advancement.*

TN 1018

COMPLETE

# hydraulic equipment

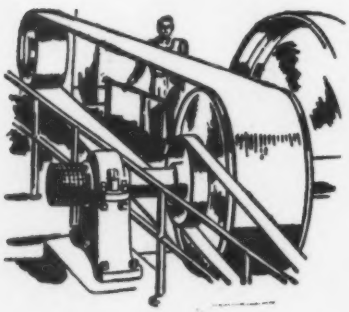
FOR WATER POWER PLANTS

View in erection shop, showing assembly of large Francis Turbines. In the background, the giant turning mill.

## J. M. VOITH - AUSTRIA

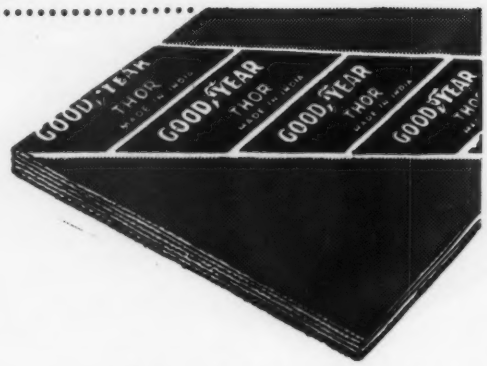
Postal Address : J. M. VOITH, ST. POELTEN, AUSTRIA, POSTFACH 168. Cables : VOITHWERK ST. POELTEN. Teletype : 01 2148

# THOR HEAVY DUTY TRANSMISSION BELTING



BETTER BELTS

FOR EVERY DRIVE BY




No matter what your belting needs, there's a Goodyear belt that will do the job better at lowest cost. Goodyear's line of belts is *complete* and covers every possible use. Let us check your installation—we'll recommend the *right* Goodyear belt for your job.

INDUSTRIAL PRODUCTS DEPARTMENT

GOODYEAR

THE GREATEST NAME IN RUBBER

PSIP 1

COMPLETE WATER POWER PLANTS

# TECHNOEXPORT

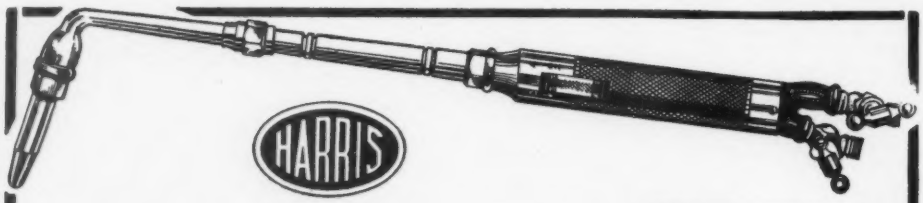
**New series of medium voltages circuit breakers**

**spring operation**

**mt type**

**Scarpa & Magnano**

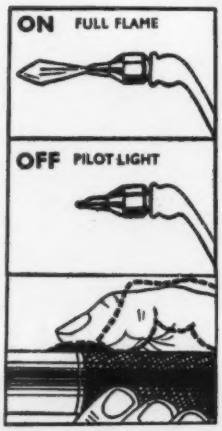
**Savona - Italy**



HARRIS

**Automatic Welding Torches**

Save time, labour and bother, money and gas by using Harris Automatic Welding Torches. They have unsurpassed operating characterestics. In several styles and sizes.



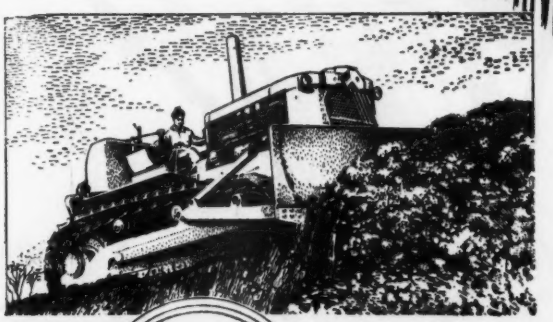

THE ASIATIC OXYGEN & ACETYLENE CO., LTD.

8, DALHOUSIE SQUARE EAST, CALCUTTA-1

AOAF 5-56

# Tomorrow's fertile farmlands

*can be built today by*



"CATERPILLAR" for :— Track type Diesel Tractors and Rubber Tyred Hauling Units, Scrapers and Wagons, Motor-Graders, Pipe Layers, Shovels, Diesel Engines, Marine Engines Electric Sets, etc.

**CATERPILLAR***

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co., U.S.A.

To reach our goal of self-sufficiency in food production, millions of acres of arid land are being reclaimed for cultivation. Huge dams are being erected, miles of canals are being dug and vast tracts of land being cleared and levelled.

In all such major projects, construction engineers and contractors everywhere invariably rely on Caterpillar equipment for their rugged strength and versatility.

**CATERPILLAR*** *Paving the way to India's progress*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co., U.S.A.

TRACTORS (INDIA) LTD.
Post Box 323, Calcutta
Post Box 66, Lucknow

LARSEN & TOUBRO LTD.
Post Box 278, Bombay
Post Box 5247, Madras

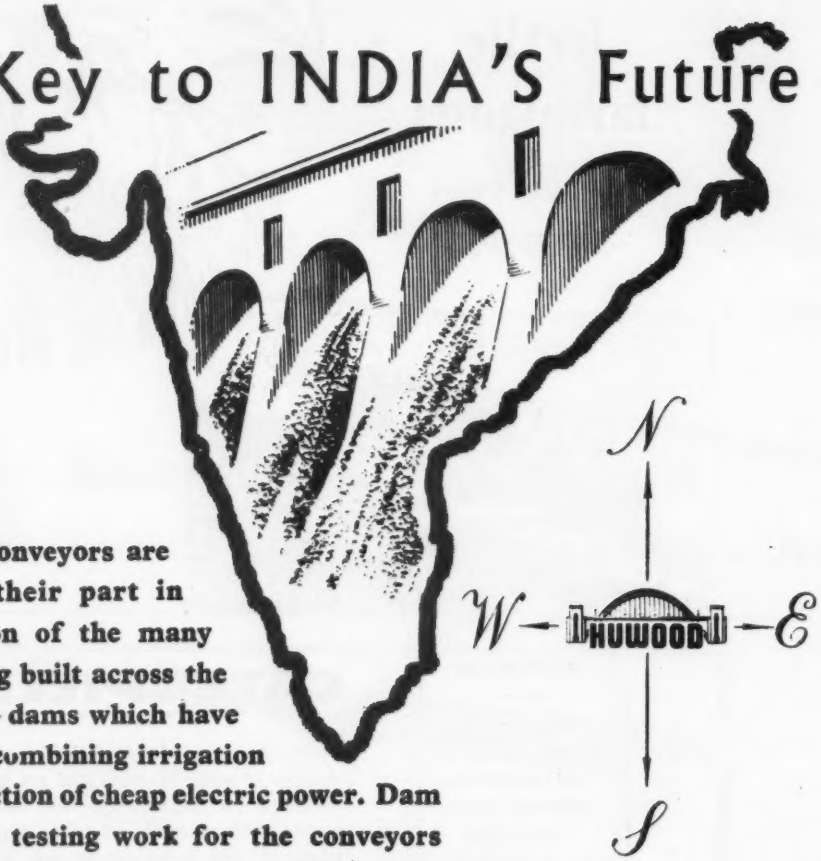
WILLCOX (BUCKWELL-INDIA) PRIVATE LIMITED
Post Box 289, New Delhi
New Colony, Jaipur

TRACTOR & EQUIPMENT CORPORATION (PRIVATE) LIMITED
P.O. Box 279, New Delhi

TI/P/22

# WATER...

## ...Key to INDIA'S Future




**Huwood Conveyors are playing their part in the construction of the many dams now being built across the Indian rivers — dams which have the purpose of combining irrigation with the production of cheap electric power. Dam construction is testing work for the conveyors employed .. contractors must be sure of obtaining equipment which is both reliable and exactly adapted to their needs.**

**Hugh Wood & Co., Ltd.,**

Head Office and Factories
GATESHEAD-ON-TYNE 11
Telegrams: Huwood, Gateshead. Telephone: Low Fell 76081 (5 lines)

Industrial and Export Office
DASHWOOD HOUSE 69 OLD BROAD STREET, LONDON E.C.2
Telegrams: Huwood Ave, London. Telephone: London Wall 8611 (7 lines)

In 1949, when the work started at Hirakud Dam, 30 LeTourneau Earthmoving machines went into operation. Jungle clearing, levelling, road making and many other jobs were done by these machines. Later on 15 more electrically controlled Tournapull Scrapers were added to the existing fleet to cope with the vast construction work. These LeTourneau machines, following a tradition of service already set in the other huge undertakings throughout the world, have moved many millions cu. ft. of earth quickly and economically.

LeTourneau Fleet at Hirakud Dam, consisted of :—**17 'C'Tournapull Scrapers of 16 cu. yd. capacity. 10 high speed rubber-tyred Tournatractors with Bulldozer attachment. 18 Super 'C'Tournapull with Tournatrailer plus many scrapers and dozers.**

**LeTOURNEAU - WESTINGHOUSE**

**Earthmoving Equipment**

**played an important role at Hirakud Dam**

*Ask Jacks about it*

**William Jacks & Co. Ltd.**

*(Incorporated in England Liability of Members Limited)*

**Calcutta Bombay Madras**

WJC-196 A

BABCOCK

*The*

# "STEAMBLOC"

***fully automatic packaged boiler***

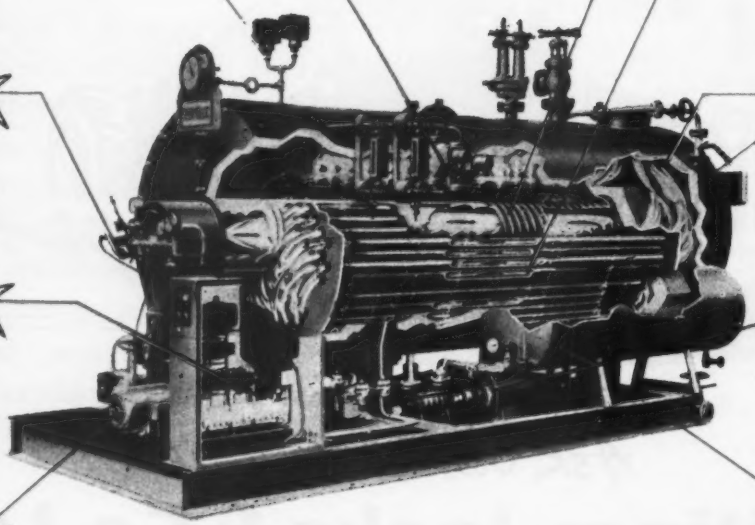
**TWIN MOBREY CONTROLLERS** providing close control of water-level with complete shutdown and alarm on low water.

**MODULATING PRESSURE CONTROL** maintaining operating pressure within close limits and incorporating high-pressure safety shutdown.

**OIL BURNER** of the well-proved fully-modulating pressure-jet type with gas-electric ignition and photo-electric cell for flame failure shutdown. Capable of utilising the heaviest grades of fuel oil available.

**CONTROL CABINET** Electronic and electro-mechanical devices ensure safety in operation and provide for purging of the gas passes before starting up, and total, immediate shutdown in the case of flame failure, low water or excessive steam pressure.

**FORCED-DRAUGHT FAN** providing air for pressure combustion and thus obviating the use of an induced draught fan and a costly chimney stack.



***Fully described in publication No. 1628/2 which will be sent on request***

**PARTIALLY CORRUGATED FLUE** for flexibility, with plain section at the burner end for maximum combustion efficiency.

**THREE-PASS BOILER** of all-welded construction to Class I requirements. The three passes provide high efficiency, maximum heat transfer and quick steaming.

**BOILER INSULATION** consisting of a layer of high quality thermal insulation, overlaid with sheet steel cleading, presenting a neat and attractive appearance.

**REAR DOOR** carried on davits for easy removal; providing full access for maintenance and cleaning.

**BOILER FEED SYSTEM** comprising supply tank, electrically-driven feed pumps and standby steam-operated injector. A float valve is provided in the tank.

**STEEL BEDPLATE** carrying the complete boiler unit, allowing easy transportation and quick installation.

## BABCOCK & WILCOX OF INDIA (PRIVATE) LIMITED

4, BANKSHALL STREET
CALCUTTA-1

16, QUEENS ROAD ESTATE
BOMBAY

# INDIAN JOURNAL OF POWER AND RIVER VALLEY DEVELOPMENT

**A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA**

Editor : K. K. Sinha — P. K. Menon : Mg. Editor

**Vol. VII** — **MARCH 1957** — **No. 3**


CONTENTS


| | | |
|---|---|---|
| THE ENGINEER IN THE DEVELOPING COMMUNITY .. | *Kanwar Sain* | 1 |
| TIDAL POWER PLANT PROJECT ON THE RIVER RANCE .. | | 8 |
| SOME PROBLEMS OF DESIGN AND CONSTRUCTION OF EARTH DAMS .. .. .. | *Raul J. Marsal and Enrique Tamez* | 9 |
| DEVELOPMENT OF TUNNELLING MACHINES : A REVIEW .. | *G. S. Marwaha* | 15 |
| KARIBA HYDRO ELECTRIC PROJECT .. .. | *Don Taylor* | 21 |
| ALL INDIA POWER ENGINEERS' CONFERENCE BANGALORE, 1957 | | 24 |
| OUR DELHI LETTER .. .. .. | | 29 |
| NEED FOR AN INDIAN ECONOMIC SERVICE .. .. | *Editorial* | 31 |


**In the coming issue :**

Hydrological Condition of the Lower Reaches of the Damodar *by* Satyakam Sen; Maximum Rainfall Intensity in Damodar Valley compared with those of North East India *by* M. Gangopadhyaya, K. C. Mazumdar & A. Krishnan; Some Problems of Design and Construction of Earth Dams *by* R. J. Marsal & E. Tamez G.; Salime Hydro-Electric Power Station; Mannual Labour Versus Machinery *by* Construction Plant & Machinery Committee.


Editorial and Managerial Offices
6/2, MADAN STREET, CALCUTTA-13. PHONE : 23-1765 & 23-5855. GRAM : TEKJOURN
Manager : B. Bhattacharya

| Delhi Office | Bombay Office | German Representatives | London Representatives |
|---|---|---|---|
| 18, Kakanagar | 41, Hamam Street | Intercont G. M. B. H. | Walter Judd Ltd. |
| Cornwallis Road | Bombay 1 | Frankfurt A.M. | 47, Gresham Street |
| New Delhi | Phone : 252119 | Kurfurstenstrasse 49 | London E C 2 |

*Annual Subscription :* Rs. 20, £2 or $6.00. *Single copy : monthly issue* Rs. 2

SHIFTING EARTH
FOR PROSPERITY

# OVER 50 'INTERNATIONAL' TD-24'S ON DUTY AT CHAMBAL

In Madhya Pradesh and Rajasthan men and machines work day and night to harness the wayward Chambal for irrigating arid lands and generating cheap hydro-electric power for industrial progress.

A very important role in this 'mighty adventure' is being played by over 50 International TD-24 Crawler Tractors which are fitted with a variety of suitable equipment to grapple with the toughest earthmoving jobs.

On this, as on other river-valley projects in India, the TD-24 is doing a magnificent job, tackling the toughest earthmoving assignments with the characteristic 'International' ease, efficiency and economy.

FOR FASTER AND BETTER EARTHMOVING

## 'INTERNATIONAL' TD-24

WORLD'S MOST ECONOMICAL DIESEL CRAWLER TRACTOR

*Backed by the largest spare parts and service organisation in India.*

VOLTAS VOLTAS LIMITED

BOMBAY • CALCUTTA • MADRAS • NEW DELHI
BANGALORE • COCHIN • LUCKNOW
AHMEDABAD • SECUNDERABAD

VOL.37.2

# The Engineer in the Developing Community

By KANWAR SAIN, I.S.E.
*Chairman, C.W. & P.C., Government of India*

There are two equally important elements in human progress. They are the development of spirit and character on the one hand, and the mastery of the physical world on the other. While improvement of character and spirit affords most promising ways for fulfilling the possibilities of life, of equal importance and significance is the mastery of the physical world to provide conditions suitable to live in and effective tools to work with. The element of physical mastery has been deprecated by sages and seers in India for centuries as of a base order. The pursuit of spiritual life has been acclaimed as nobler. But it is essential to realise that both the elements are equally essential to fulfil the functions and purposes of life.

From my extensive travels both in India and abroad, and discussions with eminent personalities, I have found a universal determination of all the nations—whether in Asia or Africa, and whatever their present state of development be—to improve their standards of living. Ninety per cent of the present population of the world has a standard of living much below that of the United States. Some fifty years ago, an American worker produced roughly the same amount of goods in a day as his contemporary did in any of the countries of Europe. He enjoyed about the same standard of living. Today he turns out from two to four times as much, and eight hours' of work buys for him nearly one-and-a-half to four times as much as that for his counterpart in Europe.

It is admittedly true that the American ways of life and their higher standard of living are not applicable to India. Deep differences of philosophy, of social and cultural outlook, and of national customs enter into the picture. Yet Indians do crave for higher standards of living ; they do want less work, more pay, an easier life, more leisure and some recreation. To this extent Indians are as human and materialistic as any other people. India cannot survive by the pursuit of spiritual walk of life alone. It may lead to absence of development and stagnation.

Without the mastery over nature, our earth, as it is, would support but a small fraction of the present population. Broad estimates made by experts indicate that the population of the world has risen from 1,100 million in 1850 to 2,400 million in 1950. They estimate that by the year 2,050, the world's population will have increased 2½ times the 1950 figures, reaching a gigantic figure of 6,000 million.

Who will the demands for the steadily and substantially rising standards of living of the world population be met with ? Will the world be plunged into an economic catastrophe ? I submit that hunger and proverty are no longer beyond solution. The mastery of the physical world around us gives the key to the problem. The most thickly populated regions on earth can be satisfactorily fed if the most effective known methods are applied. The technical possibilities of feeding the world will probably always run far ahead of the increase in population.

Research and development in nuclear physics ha opened up great possibilities of an alternative source of fuel for generating electricity. Similarly extensive study, research and development of alternative sources of food supply should be relentlessly pursued besides undertaking measures for stepping up the agricultural production of the world.

### The Role of the Engineer

As stated by Dr. Arthur Morgan,[1] at every step in the history of mankind, increase of mastery of nature has been brought about by three major factors. Foremost among them is his direct and intimate acquaintance of those elements of nature that are to be mastered. We can seldom control those with which we are not acquainted. The second important factor is understanding. Quite frequently it is the lack of perfect understanding of the several constituent forces in nature that come in the way of optimum utilisation. The third is the dexterous use of the hand, ear and eye for increase of the mastery of nature. Even the most brilliant and penetrating theory may become ineffective in controlling the environment and remaking the world without their appropriate use.

### Indian engineers have not lagged behind

The achievements of Indian engineering have been stupendous in the past few years. After the dawn of Independence, great strides have been made in the country. Problems that were never heard of confronted the infant democracy. Partition of the country was an essential prerequisite demanded for polical independence. Having accepted the inevitable,

[1] In his recent book *Search for Purpose*

transmigration of a whole mass of people was a dismal picture that scared the Government. Bold decisions and quick action produced the necessary results. The rehabilitation and resettlement of the regugees have been achieved with a great measure of success. The building programme that followed to house these these refugees was indeed praiseworthy. The national reconstruction demanded the construction of huge buildings and multi-storeyed structures for Governmental office buildings and other purposes ; new highways with incidental bridges, causeways and other crossings ; industrial townships and factories like Sindri Fertilisers capital city constructions like Chandigarh in East Punjab and Bhubaneswar in Orissa ; and many other structures of marked engineering efficiency such as the Banihal tunnel and the Vigyan Bhavan.

The river valley development in the country is gaining momentum every day. The Tungabhadra and the Lower Bhavani Dam constructions in the South were completed. The first phase development of the Damodar Valley is almost complete. Two dams, Tilaiya and Konar, and the Durgapur Barrage are already functioning. The construction of the Maithon Dam is almost over and the constructional tempo on the Panchet Hill Dam is gaining rapid pace. The Hirakud Dam with some unique features of design and construction was opened by our beloved Prime Minister on the 13th January 1957. It is the longest dam in the world measuring about 16 miles from one end to the other. The construction of the 740 feet high Bhakra Dam is progressing according to schedule and will be completed by about 1959. Koyna, Rihand, Chambal, Kosi, Nagarjunasagar and many more are under various stages of execution. An idea can be had of the magnitude of the river valley project development, when we see that the amount spent on them every year is more than what was spent during the entire century prior to Indian Indenpendence. The development is exciting and spectacular.

The Indian Railways have registered their landmarks by the construction of the Chittaranjan Locomotive Factory and the Perambur Integral Coach Factory. The engineers of the Army have contributed their mite and showed efficiency in the construction of the Napal Road— a national highway linking India with Nepal, the Bharat Electronics Factory at Bangalore, and the Machine Tools Factory at Ambernath. No less striking is the development in the branch of Posts and Telegraphs. Carrier current communication has been extended to most parts of the country and further development in the shape of coaxial cables for increasing the capacity of transmission between the main traffic centres is being extended. Wireless communication including V.H.F. (very high frequency) facilities are being increasingly used.

Free India realised the importance of research in the technological development of the country. Theoretical as well as applied research and technical "know-how" are very necessary for a marked success. Several national laboratories, technological institutions, hydrometorologic observatories and aerodynamic research stations have been established. As an instance in point I may mention here the part played by the Central Water and Power Research Station at Khadakwasla in taming the Brahmputra to save the town of Dibrugarh in Assam. It looked almost certain that the town would be swallowed up by the mighty river. Nothing short of a heroic battle for Dibrugarh was fought and today I am happy to claim that we have saved the town from further danger. This was possible because of the basic research conducted in the laboratory and the bold action in the field.

On the industrial side too, our development has been no less marked. The Hindustan Aircraft Factory, the Telephone Industry, Electric Cable Industry, Machine Tools and Oil Refineres are a few major ones of the many enterprises. Heavy industries are programmed in the Second Five-Year Plan. The stress is more on the rapid industrialisation of the country though considerable importance is attached to the agricultural improvement projects. The basic Iron and Steel Industry has been given great importance. The Rourkela, Bhilai and Durgapur Iron and Steel Plants are being pursued vigorously.

I must not fail to mention the Atomic Energy Plant at Trombay. This opens up a vast field for the utilisation of our extensive atomic energy resources.

### We must continue to grow

Our past achievements should not make us complacent and dim our vision for the future. In the inspiring words of our Prime Minister, "Let us think not so much of what we have done but of what we have left undone. Let us think also of the mighty resources of India, which, if harnessed and utilised for common good, can change the face of India and make her great and prosperous. To great task let us address ourselves with all the strength in us."

The profession of engineering is as old as the crudest shelter ever built in the antiquated past to protect our forefathers against their foes and the elements. also this profession is as new as atomic fission and nuclear fusion. This has been so because of the new environments, materials, methods and problems that are incidental to the onward march of human progress.

What was done yesterday may not suffice for tomorrow. Past practices must be re-examined and re-evaluated. A fresh approach to present and future problems must be made. Present materials must be worked harder, and new ones that are stronger and better must be developed.

In view of the shortage of steel and cement, there is imperative need for taking stock of our present-day design practices. I am afraid that many of us still needlessly waste materials by over-designing our structures. Not only do we pay higher cost for the projects in hand, but hold up some other projects for want of these essential materials. Over-design is as much defective as under-design. While under-design results in structural failure and hence has to face public criticism, over-design usually passes off unnoticed in spite of incidental extra expenditure.

There are obvious causes for over-design. Often it is the constant pressure exerted to get the jobs done quickly. The engineer in his haste makes a guess at structural sizes, a guess that is invariably conservative and hence safer. Also the traditional rule of

thumb tempts many an engineer with an easier course. Designs and details of old structures are constantly used and re-used. This is an undersirable practice which throttles all attempts at scientific improvement and technological advancement. There is a vital need to review the factor-of-safety in the light of more standardised materials and more exact methods of analysis.

We have now available techniques of design that far surpass those of even the previous decade. Quality of workmanship, while difficult to control, is not a completely unknown factor due to controlled and mechanised methods of construction.

The engineering groups in India should undertake an appraisal of the existing knowledge. They should assess the case-histories of thousands of existing structures. Reports of these findings would be an invaluable treatise for ready reference.

**Many more engineers needed**

The work of building up new India devolves on the engineering profession as it did in the building up of new America during the last hundred years and in building up the U.S.S.R. during the last twenty-five years. If we wish to increase the level of income, there must necessarily be a very big increase in the proportion of engineers and technicians to the working force. About one in 80 persons in the labour force in the U.S.A. is an engineer or a scientist. The number of working professional engineers in 1954 has been estimated as 5,35,000 in the U.S.A., 5,40,000 in the U.S.S.R., 60,000 in the U.K. and only 25,000 in India.

In the age of atomic energy, the extent to which science and technology have been made use of by a country is the index of its position and importance among the progressive nations of the world.

Over the past 25 years Russia has turned out about 3 engineers for every 2 in the U.S.A. In 1955, the ratio was about 2 : 1. In addition to these specialists the Russians are training a vast army of second-line technicians.

In 1955 alone, Russia turned out 63,000 engineering graduates, while the U.S.A. turned out 23,000 engineers. During the next five years it is estimated that Russia is going to rurn out 4,00,000 engineers and about the same number of diploma-holders. In fact, many of the Americans are getting perturbed over this lead of the U.S.S.R. in producing engineers and scientists. Thoughtful Americans have started shouting : "We are not going to increase out rate of progress merely by means of stepped-up appropriations. The greatest scarcity is in the supply of that rare commodity, the trained and creative mind. That is a scarcity that cannot be solved overnight, by Congressional action."

How does India compare ? In 1955, the outturn of engineering graduates was a little more than 3,100 and diploma-holders about 6,000. The Technical Manpower Committee appointed by the Planning Commission has given the minimum requirements as about 6,500 engineering graduates by the end of the Second Five-Year Plan. This would indicate the leeway that has to be made up if we are to be independent of other countries for all our engineering needs. Some are afraid that a large-scale increase in the number of engineering graduates may create unemployment amongst them. There is no basis for such fears.

Even in the United States and the U.S.S.R. where technical training has been carried far beyond the point it has reached anywhere else, there is today a great shortage of engineers. There are 5,000 firms that have recruiting teams in the field in the U.S.A. looking over students who will get their degree this year. The Standard Oil Company of Indiana has assigned fifteen of its top-flight research people to go round the country, seeking out engineers and technicians. The G.E.C. is looking for 2,000 and the General Motors for 900 engineers. The pay grades they offer are quite attractive, with varied opportunities for betterment. The shortage of engineers in India will continue to grow, not diminish. It is inconceivable that a generation hence India will find herself possessing surplus of such personnel. Any restriction on recruitment to small cadres for effecting economy will be highly wasteful in the long run. This is a bitter lesson that the First Five-Year Plan has taught us.

If India does not wish to remain contented by being a mere imitator and a follower, it will have to create the conditions which will permit growth in the stature of the scientist, the technician and the engineer. Are the powers at the helm of affairs sufficiently conscious of these needs ? Serious disclosures would be indicated by contrasting the total University population with the number of students taking full-time courses either in science or in technology.

**Is the present climate of India suitable for growth of engineers ?**

The most importance question which must be answered by the country is "whether the country's present climate is suitable for a bumper crop of scientists and engineers of the right calibre." You can judge the stage of growth of a nation by finding out which class of that nation, in a practicular period of history, was held in honour more than the others. There was a time in Indian history when the Brahmin, as custodian of the spiritual development, was held in the highest esteem. India produced sages and seers of the highest order. The came the period of the warrior, and later that of the landlord.

At the turn of the century, law offered the best attraction. The dispensation of justice in the courts of India depended mostly if not entirely on the ability of the lawyer to present the case of his client. There was plenty of litigation. Big landlords and others from rich families could afford to pay fat fees. High salaried seats on benches of high courts were open to them. In this climate India produced some excellent lawyers, who being free from chains of Government Servants Conduct Rules, successfully fought the country's battle for freedom.

In the last generation or two in India, the brightest boys looked to the All-India Services. At first, Indian Service of Engineers was the most coveted and a little later the Indian Civil Service attracted the best of them. These services brought considerable emoluments and a certain measure of prestige. Con-

sequently, India produced some of the ablest engineers and administrators of law and land. The former have played a significant role in the development of the counry and the latter in the maintenance of law and order and settlement of land affairs. In their respective spheres they have discharged their responsibilities most creditably. But for their existence in the cadres, the implementation of the First Five-Year Plan would not have been possible.

Then came a big change. All-India Service of Engineers was abolished along with other All-India Services except the Indian Administrative and the Indian Police Services. The best boys of the country now seek admission to these services at the cost of all others. If this tendency is not checked, the country shall have to repent as the future development plans will remain only on paper.

I have no quarrel with those who want men of grit and integrity in charge of law and order. But today the country's needs in the spheres of development are even more important.

As recently emphasised by Shri U. N. Dhebar, President of the Indian National Congress, at Indore, "In the first place the misery of our people call for for utmost urgency and, secondly, the world is marching ahead. Backward as we are, we will be still thrown back if we slacken in our effort." The dynamic change, which is the foremost need of the country, can be brought about only by an army of competent technicians and engineers. This needs a well-thought-out and long-range policy, as the supply of engineers cannot be turned on and off like water from a tap.

My contacts with engineers at various levels in the country indicate that the engineers in general are dissatisfied with their lot. They are concerned witih such problems as emoluments, professional standing, social status and collective bargaining. It is evident that a considerable number of them feel that their profession has not given them the satisfaction it should. Not only members of the profession but also those who are interested in creating a socialistic pattern of society by achieving a more rapid productivity should be concerned about this dissatisfaction. They should determine the root cause of the trouble and try to remove it.

The need of the hour is to attract the best brains in the Universities to the development and nation-building activities which have to be handled by technical and scientific men. The best interests of the country require that each individual should make the fullest use of his aptitudes and develop them so that he can exercise his capacity to the maximum in serving the country's needs. The climate in the country, however, does not encourage the bright young men to choose subjects which will fit them for technical and scientific careers. Even those who have been trained at great cost in engineering and sciences prefer to go to other careers. It is apprehended that there is a gradual drift towards the arts as compared to science subjects, in view of the comparatively easier opening provided by the expanding I.A.S. competition to such subjects. This tendency would be detrimental to the interests of the country and will be an obstacle in the implementation of the country's Five-Year Plans.

What is the cause of this tendency? It probably begins in high schools and comes to be a decisive factor in the Intermediate classes where the young student has to decide what he wants bo be. It is here that he begins selecting subjects to prepare for his future. Attractive compensation very often determines the field, professional or otherwise, to which the prospective student decides to direct his talents. He elects courses that will give him maximum dividdends in the I.A.S. competitive examination.

**Shortage of technical teachers**

The next hurdle is the shortage of competent teachers in our engineering colleges. What can be done to meet this shortage? Let us see what others have done in facing such problems. For example, Bay City, Mich., had the problem of shortage of trained teachers. A study was instituted with the help of help of Central Michigan College. They found that the teacher' traditional complaint of vast amount of unnecessary work was justified. They found that each of their 137 teachers were spending from an hour and a quarter to more than four hours every day on a combination of activities, which did not require professional teaching competence and could be included in the general phrase "house-keeping".

What did they do about it? They instituted a system for the use of teacher 'aides'. These teacher 'aides' took roll call, checked papers, recorded grades, prepared materials for teaching, gave first-aid, supervised home work—all the dozens of things that take so much of the teacher's time without requiring any of the teacher's special talents.

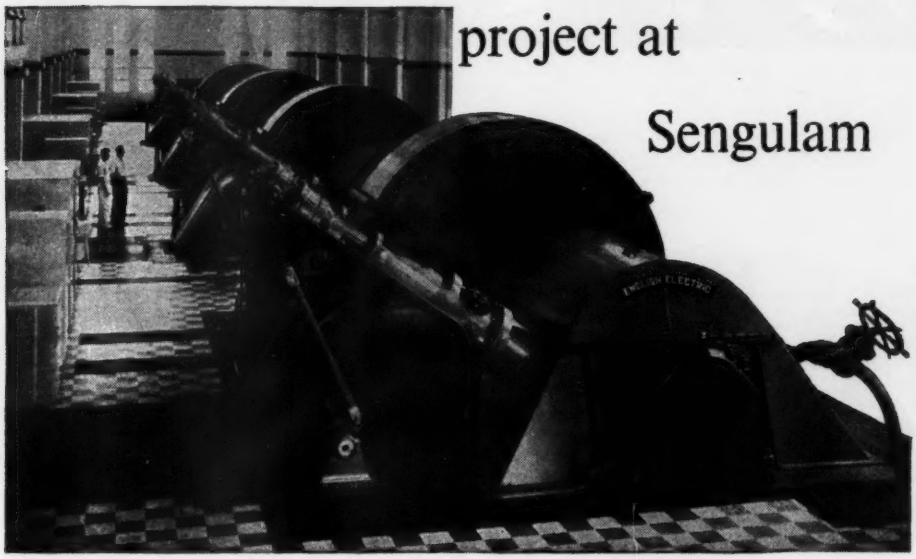
What was the result? They found that the new system made it possible for the teacher to spend an average of 23 per cent. more time on activities closely related to instruction. Many of the original aides enrolled in programmes intended to prepare them to become full-fledged teachers. A good deal of the time of engineers and engineering teachers could be saved by giving them such 'aides' to take care of all non-engineering work.

That is one solution. It is not a complete solution, and it may not be the best solution for our colleges. In Ohio there were 3 colleges that were worried about the calibre of instruction in science courses. They, too, hired teacher 'aides'. In addition, they hired 3 topnotch instructors, each a master in his own subject. These three moved from college to college like circus riders, giving each college a level of competence in those three courses that it could not have afforded on its own. Obviously, small institutions cannot afford to hire to-quality teachers for every course. Perhaps the answer lies in pooling parts of their faculties.

Teacher's pay is certainly an obstacle. It seems one of the paradoxes of our system that we pay all our teacher according to the same yard-stick. We should realise that the educational system is not immune to the laws of supply and demand.

In some areas it might be possible to have engineers volunteering to devote, say, three hours a week to teach a class in a special subject accepting a suitable honorarium. In addition, we have an increasing reservoir of engineers and scientists who have passed the mandatory retirement ages, but who are still

# Comprehensive hydro-electric project at Sengulam



The entire plant and equipment for the Sengulam Power Station in Kerala, India, was supplied by The English Electric Company. The equipment included four 36 in. dia. cylindrical-balanced high-pressure inlet valves; four 12 MW, 1,120 ft. head, 500 r.p.m. turbo-alternator sets; four 11/66 kV transformers; 66 kV and lower-voltage switchgear and control panels; and additional switchgear at the Pallivasal Switching Station.

Other comprehensive hydro-electric installations in India equipped by "English Electric" are the Radhanagri, Nizamsagar and Sarda Power Stations.

Hydro-Electric equipments have also been supplied or are being supplied for the Power Stations at Bhira, Hirakud, Rihand, Poringalkuthu, Papanasam and Mettur.

*Every aspect of hydro-electric design and manufacture is dealt with inside the company's organisation.*

**'ENGLISH ELECTRIC'** ***hydro-electric equipment***

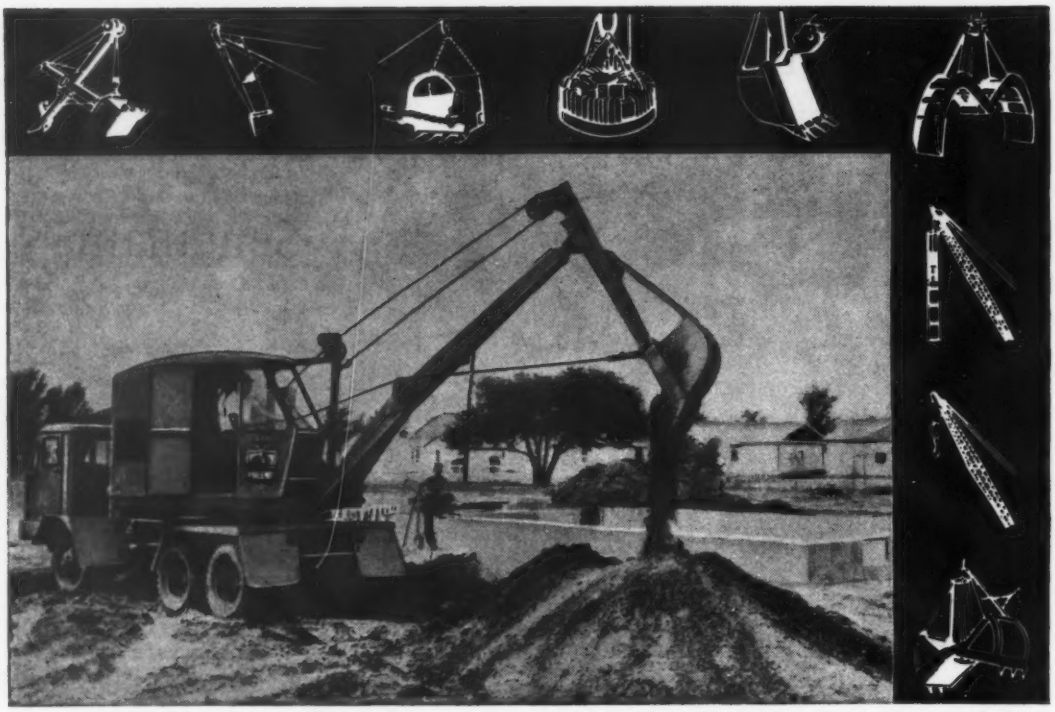
THE ENGLISH ELECTRIC COMPANY LIMITED

*(Incorporated in England. Liability of Members Limited)*

New Delhi Calcutta Bombay Madras Lucknow

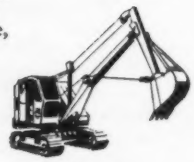
*Manufacturers of the famous* CANBERRA *Jet Bombers*

EEC-38



SCHIELD **Bantam** nine machines in one!

- America's most versatile digging, lifting and materials handling machine.
- Works fast, efficiently with nine easy-change attachments—shovel, back hoe, dragline, clamshell, crane, magnet, pile driver, grapple, backfiller.
- Saves money and time on hundreds of jobs.
- Choice of three BANTAM mountings—truck, crawler and self-propelled.
- BANTAM's easy operation and fast cycle keep work ahead of schedule.
- Six and seven tons lifting capacity as crane; ⅜ cubic yards capacity as excavator.



C-35

CR-35

See your BANTAM distributor for complete information.

SCHIELD Bantam Co.
Waverly, Iowa, U.S.A.

World's Largest Producer of Truck Cranes and Excavators

NF-39

*Sole Distributors in India*

**SOORAJMULL NAGARMULL**

*Import Department*

**8, Dalhousie Square (East) Calcutta-1**

capable of many years of service as teachers. Whatever departmental and codal barriers keep them away from rendering such service should be removed.

**Engineers in administration**

In technical departments of Government, there has been a growing discontentment during the last two decades Governments have shown distrust in the technical administrators. The technical men have a grouse that they are being progressively debarred from taking their share of responsibility at Governmental level and that non-technical administrators have been introduced between the Ministers and Heads of Engineering Departments. Even posts like General Managers of nationalised factories, for which engineers would be best fitted in view of their practical experience and analytical approach to problems, are being filled by non-technical administrators. The general experience is that this results in delays in the execution of national schemes. The relationship between persons in the Secretariat and those in the technical services is becoming more and more remote. It is true that one of the great virtues of the Indian system is the emphasis placed on generalist qualifications for the officials in top positions. But there is no single source of generalist personnel, no single formula for developing them. Some persons with technical background become competent generalists. Others are capable of transformation into generalists by diversification of their experience. I would accede that some top-level Governmental generalists have proved admirable heads of industrial organisations. Conversely, some persons recruited and put through the experience, conventional for preparation of generalists, never develop a real capacity for high level performance.

In India sometimes the very word 'administration' is too narrowly conceived as relating to financial and personnel administration coupled somewhat vaguely with other functions of the secretariat. To quote Dr. Paul H. Appleby "Administration is basically the conduct of programmes important to citizens and to the nation ; fiscal administration and personnel administration are merely aspects of the general management of a variety of programmes. Administration in India seriously needs a much more marked orientation to the conduct of programmes, because the present 'administration' is largely negative. The system of personnel management contributes importantly to this bad condition."

In accordance with socialistic pattern, the Government is entering more and more into industrial and commercial undertakings. The usual pattern of administrative service which was previously meant primarily to keep law and order will not suit the country in the presentday context. It will be necessary to change the administrative practices at least in this field. In fact, the tempo of the Second Five-Year Plan projects is so great as to require a drastic change in control methods. The difficulties and bottlenecks in the way of successful accomplishment of these projects are so great that vehement arguments are advanced for the wholesale removal of the procedural difficulties, which are only adding to the problem. The need for rapid expansion in the basic projects undertaken by the Government is so pivotal to the success of the Second Five-Year Plan that very special measures are justified.

India is, in fact, in a state of emergency quite comparable to the condition that would have obtained if the nation was at war. Its success in this emergency depends upon rapid decisions, making rapid actions possible. The present emergency is most acute on the front where new enterprises and huge projects are being taken up. As in war, the emergency dictates the establishment of procedures that have a maximum potential of acceleration consistent with the maintenance of democratic values.

One of the secrets of the phenomenal progress of the U.S.S.R. has been that the technical men are given the fullest latitude in their own fields. Even in the U.S.A. more than forty per cent of persons holding managerial positions were trained as engineers. Since many engineers are expected to rise to the positions they are developed in an atmosphere which will fit them for their future managerial responsibilities.

It is sometimes argued by the advocates of the *status quo* : "after all the index of efficiency of the present system is the achievement being made in various fields." To these plausible claims, my earnest reply is : "The fact that the country has progressed so far does not prove that it will continue to do so in the future. This progress has been made in spite of the present handicaps, thanks to the momentum gained by Independence. It could certainly be bettered." I realise that established systems cannot be changed overnight except through a violent revolution, which itself would hold up immediate progress. In the wise words of Shri Dhebar, perhaps "Much can be achieved without formal changes of rules and procedures if the official machinery functions on the basis of trustful co-operation between all ranks of services in place of the present basis of distrust and suspicion. A developmental machinery cannot afford to be coercive or suspicious. It has to function on the basis of trust and co-operation as between equals....."

Another plea often used to keep the technical men down is "Since experts' opinions are conflicting, the only possible course is to have a layman sit in judgment and decide the issue." That, I submit, is an attitude of ignorance. If a person with no knowledge of medicine should hear a discussion by medical men in which there was wide difference of opinion, it might well appear to him that since the so-called authorities disagree, one doctor's opinion is as good as another's. Would he himself dare to prescribe any medicine for the patient ? Only by having some degree of competence can one distinguish between chemistry and alchemy, astronomy and astrology or between ignorance and competence in any subject. Only if a person has qualified himself to have opinions on engineering matters will he be able to decide which opinion is better than another.

Occasionally it is claimed that the non-technical administration provides protection to the technical head agains public criticism. This reminds me on the parable of the kind-hearted elephant, who wanted to to help the little bantam hen hatch her eggs ; so he sat on them for her. Good intentions alone are not enough. In fact good intentions without good judgment might be quite expensive.

Once it is fully realised that the rapid development

of productivity is a basic essential for a socialist society, the necessity for technical administrator personnel both in the public and private sectors would be obvious. Never before was a greater and more urgent need for technically qualified men with the natural gift for management in higher administration. The ideal men for such appointments undoubtedly are those who are qualified in science and technology and who, in addition, have the inborn qualities of character, power for leadership and that rarest of all senses—commonsense—the combination of which earns the respect and confidence of others.

### Engineers in Policy-making Positions

I go a step further. I plead that even in the country's policy-making institutions the engineer-trained minds could be more helpful. The technical training of an engineer naturally develops in him the habits of exact thought. The correct analysis of various factors which may cause errors and the attainment of nearly the exact truth are essential procedures in solving engineering problems. It is this habit that would give him a better place in the policy-making institutions which have at present a preponderance of members of the legal profession.

A good lawyer when he draws a deed or other legal instrument, quite properly looks backward to follow old and sometimes almost archaic forms. A good good engineer on the contrary is constantly alert and endeavouring in the quest for new methods to solve new problems. Intellectual habits thus formed often persist and prevail. The association of more and more forward-looking engineers in the policy-making institutions would be an improvement in the present stage of development of the country.

Most of the engineers and technologists shun public appearance. They shut themselves so much in the technical cages of their own creation that today the trend is to use them merely as simple tools. This is a wrong trend and must be resisted. No doubt, the engineer should always train every nerve for bettering his professional attainment, but never at the cost of social and political segregation. He must assert his rightful place in society and be instrumental in the effective shaping on the policies of the country in which he lives and to the building of which he contributes so much. After all, what is democracy ? Is it not the organised effort of a few individuals or groups, convincing the general public for support to a particular programme of activity in the country ?

Engineers should become active in politics not to seek profit or prestige but to seek satisfaction in helping the work that ought to be done. In this modern age of technology such an acceptance of leadership is a special obligation. Machines are important but men are more important. Technological improvements are important but improvements in the art of human relation are more important.

The texture of economy and culture are rapidly changing due to frequent technological improvements brought about by engineers in their technical capacities. Our political and social institutions need also to be improved constantly in correlation with technological improvements. Unfortunately, political and social improvements seem to be lagging behind in this respect. Ethical and human values of life are suffering a set-back.

Governments that might have been adequate in bullock-cart days are absolutely inadequate in these dynamic days of jet-aircrafts and rockets. There are great opportunities for engineer-trained minds—an inspiring challenge that should be met to assist in solving the new problems in our political, social and economic institutions—problems occasioned largely by too rapid a progress in technical and technological fields.

Our democratic institutions will benefit if some engineers are willing to give part of their time to serving as members of district boards, party committees, city councils, delegations to political conventions, or members of the State or National Legislatures. We want at least a few engineers, not as technical governmental employees of whom, of course, there are now many doing most useful professional work, but in policy-forming positions of importance in which, alas, there are at present so few.

I believe that these policy-forming political positions are so important for the satisfactory performance of the engineers' professional duties and the percentage of engineers at present is so close to almost nil that every possible effort should be made to encourage engineers to seek to fill them.

Good engineering is important but a good and able Government is far more important. The engineering type of mind is so much needed today to assist in the current complex problems by cool rational analysis and sound judgment. This is the most appropriate time for the engineers to awaken and fulfil their civic responsibilities and duties.

Big engineering firms might well assist in making it easier for one of their engineer members to hold time-consuming public office. An older engineer who has been successful enough financially to provide resonably for his family needs, might well retire from active engineering work and devote the rest of his life to public service. The fact that most of such engineers would be serving at personal sacrifice with no personal interest or financial gain would contribute much to the type of objective and clear thinking so much needed for the public good.

### Need for Self-Appraisal

While I believe that the interests of the country demand that engineers should have a place in administrative and policy-making positions, I am not so sure if this Institution should be used as a union for promoting the interests of the engineering personnel. Recently Engineers Joint Countil in the United States took a poll of 66,000 members of specific classes as regards collective barganing. Seventy two per cent. opposed collective barganing for professional engineers ; sixty-six per cent. felt that collective barganing is incompatible with professional status ; only twenty-two per cent. reported that they believed that collective barganing would be advantageous. Conditions of engineer employees in India, both as regards professional and personnel treatment and financial emoluments, are getting much worse than they are in the United States. Faced with these conditions, some engineers in the country are of the opinion that the Institution may resort to unionisation in the belief that tangible results could be achieved only by pressure through collective bargain-

ing. Even though they realise that collective bargaining may not be consistent with their Charter and Constitution, they would be willing to submerge some of the principles in their attempt to get better working conditions through union activity. This obviously is a challenge not only to the profession but to those who employ engineers. In the minds of Indian engineers, both in Government and private fields, a feeling is growing that the emphasis to divest them from high responsible positions is on the imcrease. Unless this situation is rectified, the tendency towards converting professional institutions into unions may be dificult to stop.

This is likely to have an adverse effect on the professional concept of engineers, for a professional man must rely first on his own personal ability and integrity for recognition. Prestige is something that must be won. It cannot be bought or automatically accorded. It is something that one can command but never demand. In the final analysis an engineer achieves professional standing only to the extent that he accepts his responsibility to himself, to his employer and to the society.

There is need for critical self-appraisal amongst engineering circles. One cannot just push himself up the ladder or depend on some one else to pull him to the top. The fact that a man has acquired a Bachelor's Degree of Engineering does not in itself entitle him to any individual lasting recognition. It remains for each individual to prove by his own ability, integrity and conscientious application to duty that he deserves recognition. Each engineer has some definite responsibilities to his employer. Amongst other responsibilities a true professional engineer must be measured by a certain code of ethics. He must scrupulously adhere to all the pre-requisites prescribed in the code. It is impossible to maintain professional integrity without social integrity; the two supplement and complement each other.

Sometimes I have come across engineers who are more interested in having a job than in doing a job. Our code of ethics requires each engineer to act for his employer as a faithful trustee in all matters technical, whether the employer is in the public or the private sector.

Another drawback which keeps us is the attitude of mind of many engineers in this country. We must guard against the ostrich outlook. We must develop ability to face realities to adjust to changing conditions, or to abandon some cherished idea that is doomed to failure.

Every one who aspires to administrative positions should have some knowledge of the principles of cost-accounting. A fully trained engineer with some of the specialised knowledge of cost accounting at his command should have no fear of being overtaken on the promotion ladder.

The work of a truly professional engineer is so far from the routine established pattern that only he can provide the intiative, the discretion and the judgment to achieve the successful accomplishment of his particular task. Because he alone knows with what comprehensive ability and likelihood of success he approaches his assignment, the professional engineer must accept individual responsibility. Any attempt to use the Institution as a Union would compromise our high professional standards.

We, as a body, want and strive to deserve recognition for service to the well-being of the masses of our poor country. At this critical juncture of our country's development we want engineers of grit and integrity,

"Men whom the lust of office does not kill
Men whom the spoils of office cannot buy."

The nation cherishes the fond hope that our Institution would produce such men for the implementation of our development plans. Shall we fail her at this critical juncture? (*Being extracts from his Presidential Address at the 37th Annual General Meeting of the Institution of Engineers (India) at Trivandrum in January*, 1957)

---

*Continued from page* 8

**Tidal Power Plant Project on the River Rance**

The nominal rated output of the power will be 342,000 kW, with an annual capacity of 800 million kWh. The saving in coal consumption would be equivalent to that effected by 1,000 million kWh. capacity hydroelectric installations such as those of the Rhine and Rhone rivers. At times of peak load, the Rance power plant will be able to provide 282,000 kW. (the average winter peak demand); and under normal continuous service, 140,000 kW. (the average normal winter demand).

It is interesting to compare the corresponding figures for the Vogelgrun project (France), on the Rhine river, which is scheduled for implementation under the second part of the overall development scheme. This Rhine river plant will cost 24,000 million francs, will have a capacity of 750 million kWh., and will supply 45,000 kW. under normal load and 53,000 kW. under peak load This comparison gives some idea of the exceptionally advantageous features of the Rance project.

---

# Tidal Power Plant Project on the River Rance

By reason of its extensive basin and the considrable rise and fall of its tidal waters, the River Rance has for long been looked upon as a particularly suitable river for the setting up of a tidal power plant.

Over the past fifty years the subject has received a great deal of attention, and numerous papers have been published by various authors. The best known of them are by Meynard[1] and Boisnier, chief engineer of the *Ponts et Chaussees*; the latter author's contribution appeared in 1921. A number of applications for concession have been made. Comprehensive proposals were presented to the appropriate Ministry by Messrs. Parisot and De Tregomain; the most recent, dating from 1932, was put forward by a Company known as the *Societe Maremotrice de la Rance* (Somara), which submitted a plan for the harnessing of the entire estuary in successive stages.

Then in 1942 a new project was suggested, involving the damming of the Rance at Port Saint-Jean,

But all these projects were rejected in favour of that drawn up by the *Electricite de France*, known as the "1951 Project", on which the application for the concession submitted on March 26th 1952 was based.

Subsequently the harnessing of the Rance was the subject of official surveys carried out in the Departements of Ille-et-Vilaine and the Cotes-du-Nord, and among the various public authorities concerned. The Departmental Councils all gave their unanimous approval, and no objections were raised by theDepartmental Commissions on the sites. This "1951 Project" comprised the installing of twenty-six vertical Kaplan generator units, each with a nominal power rating of 8,000 kW, together with ten sluice-gates, 6 of them on the right bank and 4 on the left bank; in addition, a lock on the left bank was planned, to allow for the carrying out of the work. The dyke between the Pointe de la Brebis (on the left bank) and the pointe de la Briantais (on the right bank), which was to carry the power plant, was to be about 2,300 feet long.

This plant would make use exclusively of the simple running out of the water, without pumping. Its annual capacity was estimated at 550 million kW.

Whilst the application for the concession was under consideration, a technical development of great importance took place—the perfecting of "bulb" generating units. These units, especially suitable for producing power from a low head of water, can operate in various directions. Thus they could enable the waters of the Rance to be harnessed to miximum advantage.

As a result, a new project was prepared during 1954, and ultimately adopted. The "1955 Project", as it was called, comprised "bulb" units of the Kaplan with blades adjustable to beyond 2009, with an alternator within each bulb. This arrangement is admirable to the following six basic operations: Inward (sea to estuary) driving of turbines; outward (estuary to sea) driving of turbines; inward pumping; outward pumping; inward sluicing; outward sluicing.

The plant will operate on a variable cycle principle; depending on the time of high tide, the height of the tide, and the variation in energy in any given day, the most appropriate choice can be made for that day from among the many possible cycles available. In this way the energy produced by the tidal power plant can be regulated to keep pace with consumption demands, either concentrating its output on peak consumption times, or distributing electrical energy where required so as to economise on coal consumed by steam power stations. At twenty-four hour's notice, the plant can operate either in the former manner, using the stored-up energy of the river to meet peak loads, or in the second way, taking up the tidal movements directly and transforming them directly into electrical energy for immediate use wherever needed. Thus in the overall electric power production system, the Rance plant will be designed to cope with steady demands or peak loads as and when they arise.

The new project, to be carried out on the above lines, will still be on the site of the 1951 project, between the Pointo de la prebis (on the left bank) and the Pointo de la Briantais (on the right bank). the 2,300-feet long dike carrying the plant will necessitate over 16 million cubic feet of concrete. On the left bank, a lock will ensure the passage of ships between the estuary and the sea. The plant itself will be in the form of a tunnel, the top of which will be at the +15 level (+49′2″); the highest tide level is +13.5 (+44′3″). All the equipment and machinery is to be installed inside this dike, and will comprise:

—389,000 kW., 88.2 r.p.m. bulb generators, providing energy for distribution at 220 kV;

—10 sluice-gates helping to control the filling and emptying of the estuary necessitated by the plant's operation.

The fitting and maintenance yards and workshops for the generators will be in body of the dam itself, at each end, above the sluic-gate area. The one-piece design of the units clearly makes possible a simple and reliable overall plan of construction. Any unit that has to be removed for repair or maintenance can simply be lifted out, and in a matter of a few hours a replacement will be in position. The cost of the undertaking, estimated on the basis of 1954 prices, will be in the region of 32,000 million francs.

Tenders were invited at the end of July 1955, and the work itself is likely to last from 1956 to 1963. In the winter of 1963 the last of the 38 units is expected to go into service; the first 8 to 10 units will have begun working four years after the commencement of the project, and another 8 to 10 units two years after that.

[*Continued on page* 7

[1] "Revue Generale de l'Electricite", December 1918.

# EL NIHUIL HYDROELECTRIC POWER STATION

• ARGENTINA •

ON 4-23.000 K V A SETS WITH
FRANCIS TURBINES-MANUFACTURED
SUPPLIED-DELIVERED AND
ERECTED COMPLETELY BY

**M/S ANSALDO S. GIORGIO**

**GENOVA - ITALY -**

*AGENTS FOR INDIA:*
**KAMANI ENGINEERING CORPN. LTD.**
Bombay — Calcutta — Madras — New Delhi.

SPHINX 13

# Vital projects...

In India, all around us, power runs to waste in the form of unharnessed water resources.

Power is absolutely essential for the success of our 2nd Five Year Plan. Ruston-Bucyrus Excavators play a really important role in the completion of these 'vital projects'. Over 300 of these excavators are already in use all over India ... helping construction to go ahead of schedule.

**GREAVES COTTON & COMPANY LIMITED**

1, Forbes Street, Bombay 1.
*Branches* : Ahmedabad · Bangalore · Calcutta
Coimbatore · Kanpur · Madras · New Delhi

GC-24

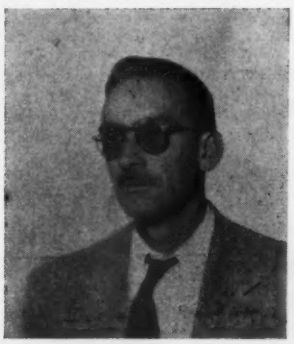
# Some Problems of Design and Construction of Earth Dams

By RAUL J. MARSAL AND ENRIQUE TAMEZ
*Research Engineers of the Secretariat of Hydraulic Resources of Mexico*

For the last 25 years, Mexican engineers have been engaged in an intensive program of dam construction, compelled by the need of developing the hydraulic resources of the country, with the main purpose of increasing agricultural production to satisfy the internal demand for such products. Although Mexicans still depend on dry farming crops, which are exposed to all sorts of eventualities due to the predominance of semi-arid climate in this country, the increment of productivity caused by the development of about 2 million hectares during the last two decades is noticeable. The use of water for power generation purposes has also grown accordingly. At the present, the installed water power capacity amounts to 1.2:million kW.

Dams of various types have been built, according to the topographic and geological conditions of the sites chosen, as well as to the materials available in the vicinity. But among them, the most frequent one, for both technical and economical reasons, has been that constituted by a core made of impervious compacted soil, protected by substantial rock or gravel and sand shoulders, or a combination of both. Such type will be referred to as an earth dam.

This article will deal with the most important aspects of design and construction of the dam from the standpoint of Soil Mechanics, as they are treated in Mexico. All the information on the subject has been collected from the files and publications of the Secretaria de Recoursos Hidraulicos (SRH), which is the government organization in charge of the execution of preliminary and final studies, design, and supervision of the hydraulic works constructed in this country, except for those carried on by the Comission Federal de Electricidad for power generation exclusively.



R. J. MARSAL

E. TAMEZ

## General Features

The most convenient capacity of a reservoir for irrigation purposes is determined on the basis of hydrological data, topographic and geological studies of the pond area, available land to be irrigated, and economical aspects.

The total volume of the reservoir is composed of the "active" capacity, and the "silting" capacity which is determined according to special characteristics of the stream as far as sediment transportation is concerned. A period of 50 years of useful life of the structure is customarily considered in such determination, and the minimum pool elevation is fixed in this manner. Spillway crest elevation is selected to provide the necessary total capacity, based on topographic data.

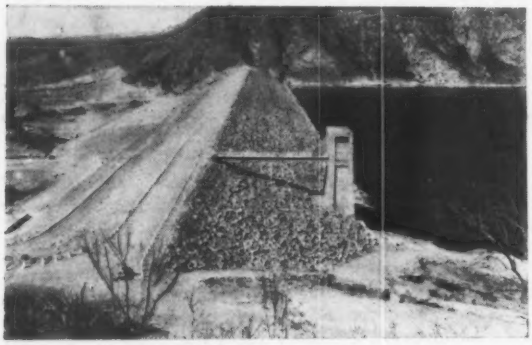
The capacity of the spillway is governed by the maximum probable flood at the proposed dam site. A routing analysis of such flood is conducted to take into account the effect of both spillway length and reservoir capacity on the peak discharge. From such an analysis the maximum elevation of the water surface is determined. Dam crest elevation is the result of adding the free board allowance to the maximum water surface elevation.

Except for a few instances, most of the spillways constructed for earth dams are of the free-crest type. The hydraulic behavoiur of every spillway is studied on a scale model of a preliminary design, which is afterwards modified according to the findings of the laboratory. The prototype is then constructed on the basis of the modified model.[1]

The maximum flood is selected by means of analysis of the river flood data. When the observation period of such data is short, they are supplemented by special studies of basin characteristics and maximum rainfall. In those projects where no rainfall or run-off data are available at all, or the observation period is considered too short, it is resorted to the procedure of basin comparision.[2]

As to the free board, it is given in such a way that, within a certain safety margin, it will take care of the wave height in the reservoir computed from well-known semi-empirical formulas.

Based on studies of the available materials in the vicinity of the site, as well as on foundation characteristics, several alternatives are considered in order to determine the most economical solution that satisfies the safety requirements normally accepted on any structure. Due to abundance of rock, most of the large earth dams constructed in mexico have substantial rock shoulders.[3] Figure 1 (printed separately) shows the cross sections of some of the dams designed by the SRH.



**ALVARO OBREGON DAM.—An earth-fill and embankment dam, 300 feet high, 11 million cubic yards of volume, with storage capacity of 2.5 millions acre-feet, built on the Yaqui river for the irrigation of 500,000 and power development.**

The dams are presently constructed by natural enterprises on a contract basis, under the supervision of SRH technical personnel. Some time ago, construction was done under direct administration ; such system was abandoned at the time the construction volume increased noticeably since 1940. The contract system has proven more economical and the jobs are completed in a shorter time.

## Construction Materials

The desirable materials which should be found at the site are : earth for the impervious core, sand and gravel for the filters, and rock for the shoulders. In certain instances, when gravel and sand are available in large amounts, it can be more economical to use such materials for the shoulders instead of rock, protecting the upstream slope against wave action with a rock rip-rap, and the downstream slope against erosion.

In order to determine the amounts of earth, sand and gravel economically available and to obtain samples of them, a detailed exploration is necessary. Open pit excavations are conveniently distributed in the potential borrow areas. Geological exploration and laboratory analyses are generally sufficient to know the quality and quantity of the rock, as well as the most convenient excavation method.

Exploratory works of the SRH are carried on by both the Geology and Experimental Engineering Departments, auxiliated by the Consulting Department.

Open pit excavations in the earth borrows are distributed on a square net, 100 to 200 meters apart from each other, depending on local conditions. Integral samples weighing about 50 kg are secured from each pit, and a visual classification of the various strata is made by men in charge of exploration. The depth of such open pits varies according to characteristics of the materials, and it is determined considering that with the usually excavation and transportation equipment it is economical to excavate to a depth of 4 to 6 meters The samples properly identified are sent to the Experimental Engineering Laboratories, where the corresponding tests are performed.

A similar procedure is followed for sand and gravel deposits, which are also studied by the Laboratory, in order to determine their suitability as agregates for the concerete required in the various structures of the dam. Indentification and accelerated weathering tests are also run on rock specimens whenever doubts arise regarding its quality.

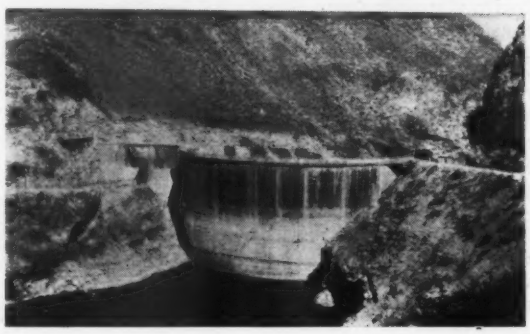
## Representative Samples

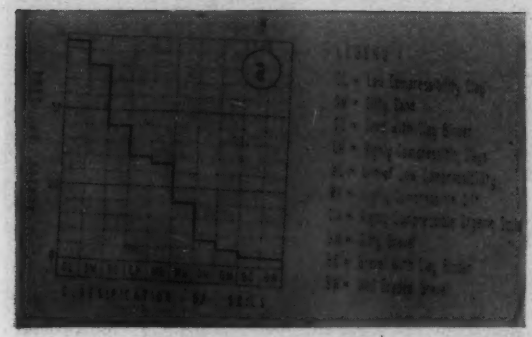
At the Laboratory, all soil samples are systematically subjected to classification tests, such as natural water content, specific gravity of solids, Atterberg limits, grain size distribution, and in some cases unconfined compression strength of specimens prepared with optimum water content.[4] From this information, soils are classified according to the Unified System of Soil Classification, which has been adopted by the U.S. Corps of Engineers and the U.S. Bureau of Reclamation.

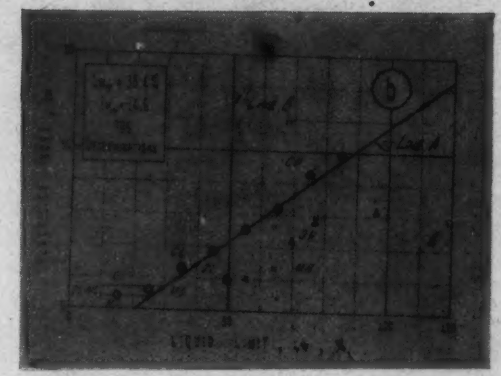
Figure 2a represents a frequency polygon of the various types of soils that have been used in the impervious cores of dams constructed by the SRH. It can be seen in this figure that low plasticity clays (CL) and silty sands (SM) are the materials more frequently used, and that organic soils (OH) represent only 3% of the total number of cases that were studied by the Laboratory. The plasticity chart of figure 2b shows average values of the plasticity index corresponding to 10% intervals of the liquid limit. Those points representing organic soils are below Casagrande's "A line"[5]. The materials considered in this analysis shows average values of 38.4% for the liquid limit and 23.8% for the plastic limit, with probable deviations of 8.3% and 7.4% respectively. Specific gravity of solids varies between 2.4 and 2.8 (Figure 2c).

In estimating priliminary excavation costs, it is important to know the degree of compactness and

**ANGOSTURA DAM.—A concrete arch 300 feet high and 250,000 cubic yards of volume, with storage capacity of 680,000 acre-feet, built on the Bavispe river.**





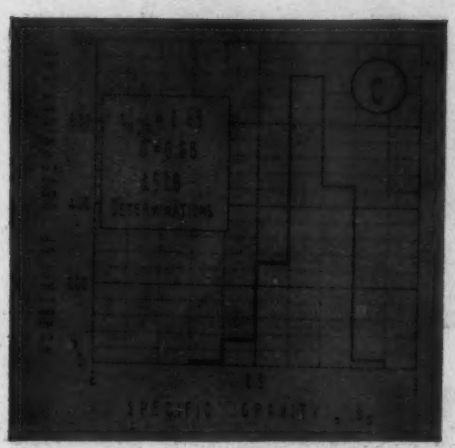


## PLASTICITY CHART

o Average values for all the soils tested by the S. R. H. Laboratory.

X Agostitlan Dam.

◂ Santa Ana Acaxochitlan Dam.



## HISTOGRAM OF THE SPECIFIC GRAVITY

*NOTE : $\sigma$ = Standard deviation*

# ORGANIC SILTS

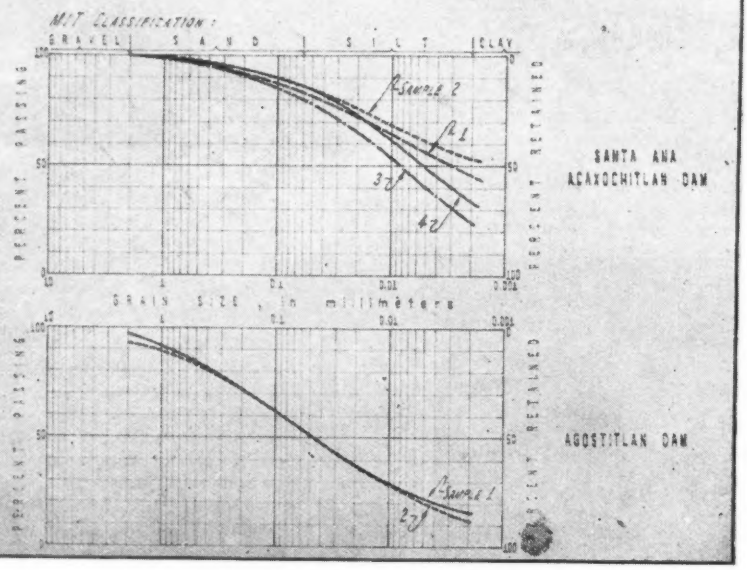
## MECHANICAL PROPERTIES

| DAM | SAMPLE | MECHANICAL ANALYSIS (% in wt) (TOTAL SAMPLE) | | | | ATTERBERG LIMITS (FINER THAN N°40 SIEVE) | | | | | $s_s$ | STANDARD COMPACTION (FINER THAN N°4 SIEVE) | | | | CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | G | S | M | C | Lw | Pw | Sw | Iw | Is | | $\gamma_d$ | $W_c$ | $e_c$ | $G_o$ | |
| | | % | % | % | % | % | % | % | — | — | — | kg m$^{-3}$ | % | — | % | |
| SANTA ANA ACAXOCHITLAN | — | 0 | 17 | 37 | 46 | 70 | 48 | 32 | 22 | 18 | 2.74 | 1350 | 30 | 1.04 | 79 | highly compressible organic silt (MH-OH) |
| | 1 | 0 | 14 | 33 | 53 | 77 | 49 | 37 | 28 | 12 | 2.77 | 1280 | 34 | 1.16 | 80 | |
| | 3 | 0 | 20 | 56 | 24 | 144 | 94 | 41 | 23 | 50 | 2.48 | 889 | 66 | 1.80 | 93 | |
| | 4 | 10 | 14 | 52 | 34 | 96 | 65 | 38 | 31 | 27 | 2.65 | 1021 | 52 | 1.60 | 86 | |
| AGOSTITLAN | 1 | 1 | 43 | 38 | 18 | 64 | 51 | 37 | 13 | 14 | 2.73 | 1270 | 37 | 1.15 | 88 | highly compressible organic silt (MH-OH) |
| | 2 | 7 | 39 | 42 | 12 | 49 | 39 | — | 10 | — | 2.65 | 1290 | 37 | 1.05 | 93 | |

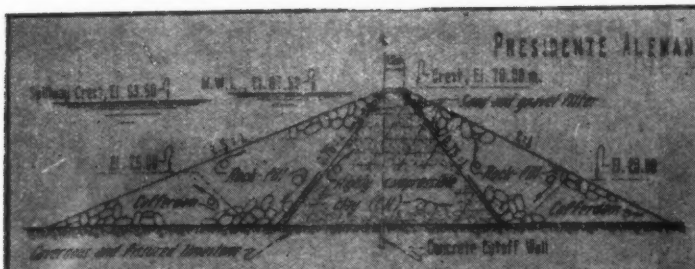
G = Gravel
S = Sand
M = Silt
C = Clay

Lw = Liquid Limit
Pw = Plastic Limit
Sw = Shrinkage Limit
Iw = Plasticity Index
Is = Shrinkage Index

$s_s$ = Specific Gravity
$\gamma_d$ = Dry Unit Weight
$W_o$ = Optimum Water Content
$e_c$ = Void Ratio
$G_o$ = Degree of Saturation

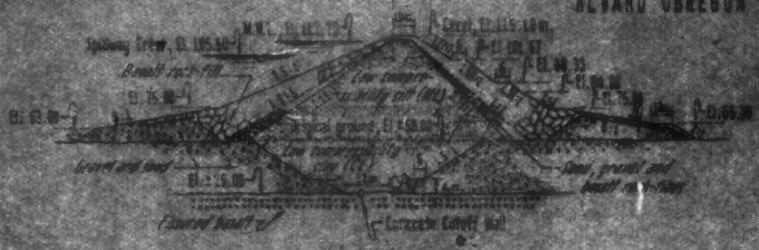


**PRESIDENTE ALEMAN DAM.**- State of Oaxaca ; built on the Tonto River, Papaloapan Basin.- Total volume of the Dam: 8 257 000 m³ ; total capacity of the reservoir : 8 300 000 000 m³.- Purpose : Flood control and electric power (154 000 KW)

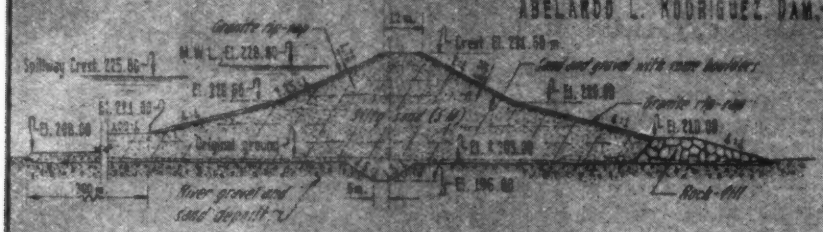



**SANALONA DAM.**- State of Sinaloa ; built on the Tamazula River.- Total volume of the Dam: 4 900 000 m³ ; total capacity of the reservoir : 345 000 000 m³.- Purpose : Irrigation of 95 000 Ha. and Flood control.

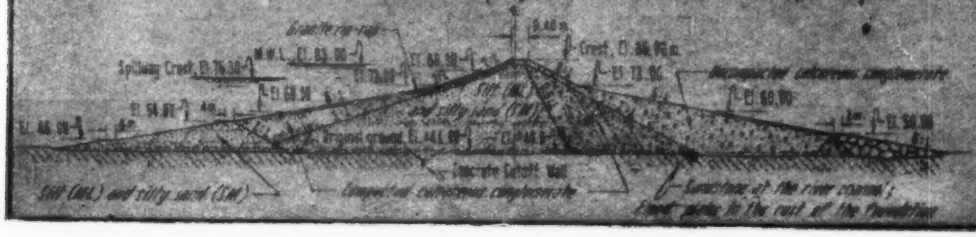
**ALVARO OBREGON DAM.**- State of Sonora ; built on the Yaqui River.- Total volume of the Dam : 9 550 000 m³ ; total capacity of the reservoir : 3 038 000 000 m³.- Purpose : Irrigation of 220 000 Ha , electric power ( 28 500 KW ) and Flood control.



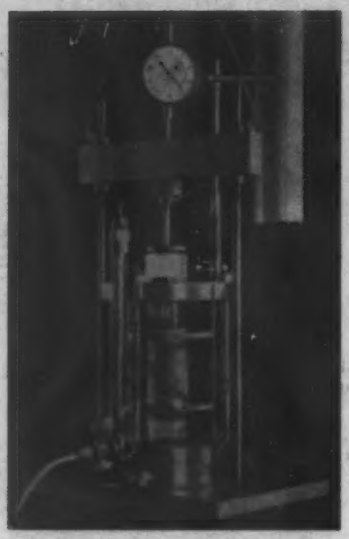

**ABELARDO L. RODRIGUEZ DAM.**- State of Sonora ; built on the Sonora River.- Total volume of the Dam: 3 091 000 m³ ; total capacity of the reservoir , 250 000 000 m³.- Purpose: Flood control and irrigation of 15 000 Ha.

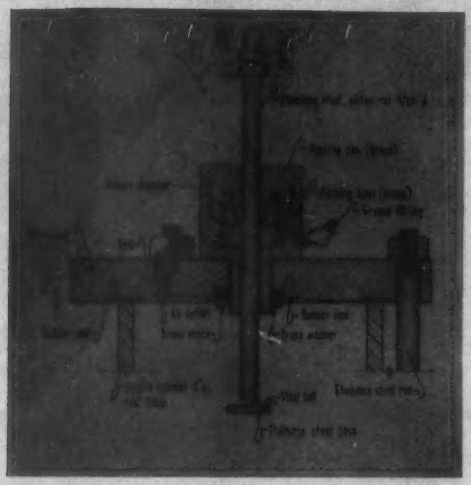



**MARTE R. GOMEZ DAM.**- State of Tamaulipas ; built on the San Juan River.- Total volume of the Dam : 4 750 000 m³ ; total capacity of the reservoir : 1 000 000 000 m³.- Purpose : Irrigation of 70 000 Ha.

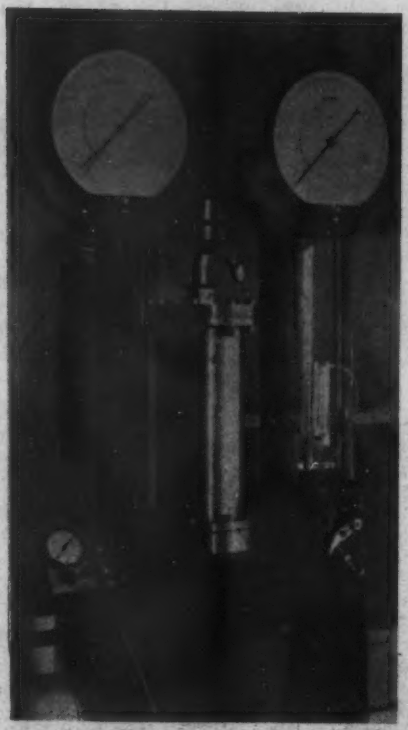


# TRIAXIAL COMPRESSION APPARATUS
## FOR TESTING SPECIMENS 1.4″ IN DIAMETER





## TRIAXIAL COMPRESSION APPARATUS
### FOR TESTING SPECIMENS 6″ IN DIAMETER



water content of the material in the borrow; such values can be determined by means of simple tests (uncomfined compression and dry unit weight). A number of different soils have been handled during construction of the various dams, ranging from cemented silty sands, which have required the use of explosives, to loose aluvial deposits.

The purpose of the classification tests mentioned above is to know the type of soils available in the site of the dam, in order to anticipate the problems that may arise from its use in the impervious core. It is well-known that, except for a few rare instances, soils vary appreciably within a given borrow pit. This fact makes it difficult to the engineer to decide upon the values of the mechanical properties which he should use in design. On the other hand it is unpractical to perform triaxial compression, consolidation and permeability tests on all the samples that come into the laboratory because of the long time they require. For these reasons, the SRH Soils Laboratory runs classification tests systematically, in order to select those samples which are representative of the materials found in the borrow. In most of the cases, as a result of these tests, the borrow is divided in more or less well-defined areas. Within each of such areas, the soils are quite similar and their mechanical properties can be studied on the basis of a few samples. Selection of samples is a very delicate matter, since test results have a direct influence on dependability of the stability analysis.

Once the samples corresponding to the various areas of the borrow have been chosen, they are subjected to the following tests: standard compaction, shearing strength, compressibility and permeability.

### Standard compaction

In order to determine the optimum compaction condition of each soil, compaction tests are run following the procedure established by Proctor, which has been slightly modified to adapt it to the needs of construction in Mexico. Test embankments are made in large dams to determine the most convenient thickness of the layers and number of roller passes. The minimum degree of compaction required is 95%, and control is exercised during construction by means of dry unit weight and water content determinations.

### Shearing Strength

Shearing strength is determined at the Soils Laboratory by running three types of triaxial compression tests, namely, quick, consolidated-quick, and slow tests.[4] Such tests are performed on cylindrical specimens 3.6 cm in diameter and 8 cm in height prepared with the fraction of soil that passes the No. 4 sieve. If gravel (retained in No.4 sieve) constitutes a large percentage of the soil, tests are run on specimens 15 cm in diameter and 40 cm in height, which include gravel frangments up to a size of 5 cm. The specimens are prepared by compacting them in special moulds until a void ratio equal to optimum and a saturation degree of 95% or higher are reached. Some materials are compacted with optimum water content and its saturation degree is increased by circulating desired water through the specimen. The triaxial compression equipment used by the SRH is shown in figure 3.

A triaxial quick test (Q) is performed in such a way that the water content and the rate of deformation are kept constant throughout the loading process. Lateral pressures of different values are applied to various specimens of the some soil sample, and the load that produces failure for each lateral pressure is measured. With this data, a series of Mohr circles is drawn, the envelope of which represents the variation of shearing strength with normal stresses, when no internal readjustment of the structure (consolidation) under the action of external forces has taken place. Such stress conditions are assumed to duplicate, approximately, the stress coditions of impervious materials in the core at the time of completion of the dam. It should be noted that specimens are prepared with a water content close to 100% saturation and that, by the time the dam is completed, some consolidation has taken place in the lower layers. Consequently, the results of quick tests are somewhat conservative when they are applied to the stability analysis of the dam for initial conditions (construction just ended). The results of triaxial quick tests, run

**RODRIGUEZ DAM.—An Ambursen type dam, 190 feet high with a cut-off wall 300 feet deep, built on the Tijuana river.**

in the manner above described, not only include the effect of pore pressures that may develope during construction, but also those that occur during shear.

In a consolidated-quick test (Qc), complete consolidation under lateral pressure is allowed before applying the axial load that produces failure. During the application of such load, changes in the water content of the saturated specimen are prevented by keeping the drainage outlets of the triaxial chamber closed. A Mohr envelope is obtained from a series of this type of tests run with different values of lateral pressure. It is assumed that this envelope represents the shearing strength of an element of soil within the impervious core, when such element has been consolidated under the weight of the upper layers and it is subjected to the effect of a quick failure.

Finally, the slow test (S) differs from the preceding one in that, after consolidation of the specimen under the lateral pressure has taken place, axial stresses are increased at a slow rate such that the intergranular stresses are kept equal to the total external stresses throughout the test. The drainage outlets remain open and water content varies according to volume changes of the specimen. Tests of this type are seldom run at the SRH Soils Laboratory since, for the compacted-soils used in embankment construction, failure envelopes given by slow and consolidated-quick tests are very similar. The difference between the two envelopes is caused by pore pressure developed at failure in the Qc test, due to the process of shearing. Thus, the Qc envelope is assumed to duplicate, more accurately, the actual state of stresses of the consolidated, saturated soil mass at failure; or in other words, the final working conditions of the material in the dam, in case of a slope slide.

### Non-Cohesive Soils

It is a well-known experimental fact, that in sands and gravels, shearing strength (s) is a linear function of effective normal stress ($P_e$) and is expressed by the following equation

$$s = P_e \tan\psi$$

where S is the so-called "angle of internal friction." This equation is valid for either dry or saturated condition, but the factor $\tan\psi$ varies with the relative density * of the soil, angulosity of the particles and grain size distribution. Due to the high permeability of these soils, it is admissible to assume that their structure adjusts itself to external forces as soon as construction progresses. In this fashion, it may be said that there is no sense in performing quick triaxial tests on such materials when saturated.

The most important of all factors that influence shearing strength of non-cohesive soils is relative desity, because of its direct relationship with volumetric changes (dilatancy) of the material when it is subjected to shearing stresses.[6] From this point of view, it is possible to define two limiting states: loose and dense. If a loose sand is tested under triaxial compression, it is observed that its volume decreases as an external axial load is applied, keeping the lateral pressure constant. But if the same soil is compacted to a dense state, its behaviour is exactly opposite under the same stress conditions; that is, it expands when axial stress is increased. This experimental fact has direct bearing on the strength s of a saturated soil. Regarding the water as incompressible with respect to the granular structure, if the soil tends to reduce its volume of voids (loose state), the applied external stresses are transmitted to the fluid of the pores, inducing upon it a pressure (u), known as "pore pressure," that decreases the intergranular stresses to a value (p-u) which is called "effective pressure" ($p_e$). In this manner, for a given total stress (p), shearing strength is smaller than that corresponding to the same material in a dry condition ($s_o$). If a saturated sand is in a dense state, its shearing strength becomes larger, because the expansion tendency of the sand creates a partial vacuum condition in the pore water, that increases the intergranular stresses and gives a value of s larger than $s_o$ for the same stress p.

Well graded sands and sand-gravel mixtures are found in a relatively dense state, either in natural deposits or in man-made structures. The angle $\psi$ varies, in general, between 30° and 45°. The soils used in Sanalona and Abelardo L Rodriguez Dams belong to this group; their failure envelopes are shown in Figure 4.

**CALLES DAM.—A gravity-arch dam, 210 feet high, with storage capacity of 300,000 acre feet, built on the Santiago river.**

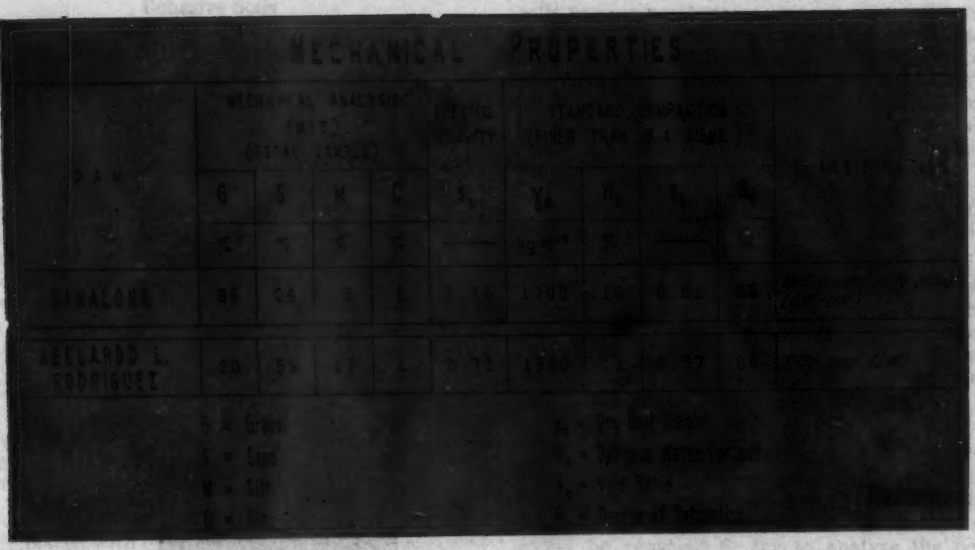
Fine, uniform sands have a loose structure, specially when their relative density is smaller than 50%. When saturated, they may lose completely their ability to resist shearing stresses, due to the tendency to reduce their volume and transfer the intergranular pressures onto the water.[7] Natural soil deposits of this type are apparently firm; their granular matrix is stable due to the effect of capillary forces developed as a result of a low water content. But when these materials becomes saturated, large sudden settlements or important slope slides frequently occur.

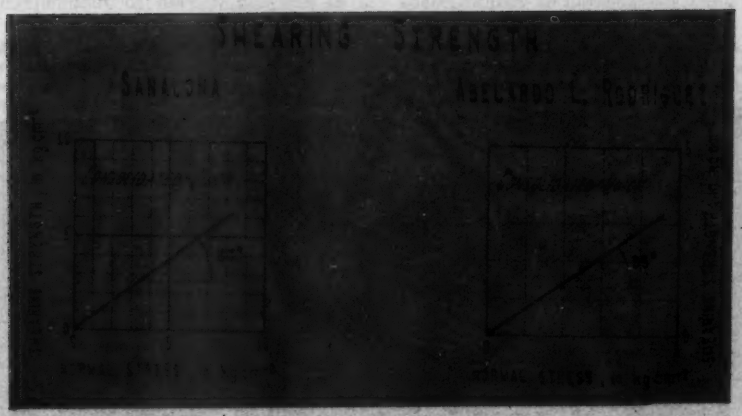
Deposits of fine material which are a by-product of hydraulic mine-dredging operations show similar characteristics to those described in the preceding paragraph. In Mexico, an extraordinary example of failure of such a deposit occurred some 20 years ago. The whole town of Tlalpujahua, State of Mexico, was destroyed by the rapid flow of the material in a "liquefied" condition, induced probably by an earthquake.

Fine, uniform sand layers in the foundation of a

* Relative density is defined as the ratio $\frac{e_1 - e}{e_1 - e_d} \times 100$ where e, ed, and $e_1$ are the void ratios corresponding to natural, dense and loose conditions respectively.

# COHESIONLESS SOILS

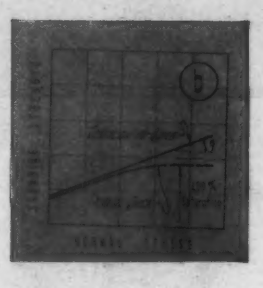


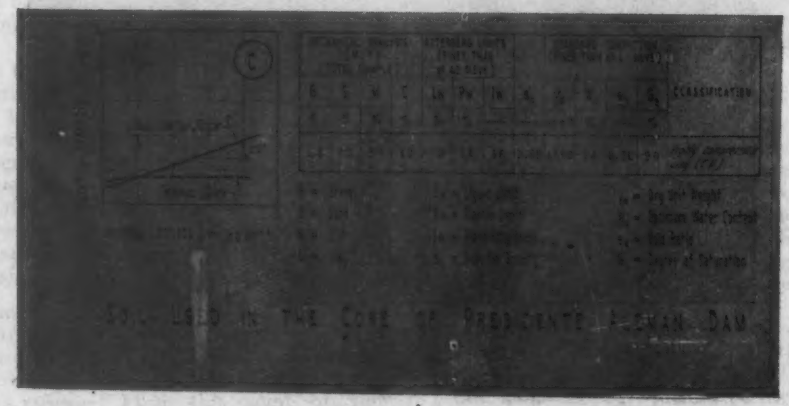



# COHESIVE SOILS

SATURATED COHESIVE SOILS

PARTIALLY SATURATED
COHESIVE SOILS





dam may cause important, sudden settlements and endanger stability when they are not previously compacted.

### Cohesive Soils

Soils with a high clay content have some shearing strength (s) even when they are not subjected to confining pressures (cohesion). When saturated, the value of $s$ is a hyperbolic function of the water content (W). Consequently, the results of the three types of triaxial tests are appreciably different since different changes in the water content are allowed in each type of test. In a consolidated-quick test for example, water content decreases during consolidation of the specimens, whereas in a quick test $W$ is constant. For this reason, the shearing strength $s$ of cohesive soils in a Q test is independent of normal pressure $P$, whereas in a Qc test it is a linear function of $p$ for normal pressures larger than a certain value $p_1$. For $O \angle p \angle p_1$, the failure envelope is generally a curve that is higher than the straight line defined in the interval $p \nearrow p_1$ (see figure 5-a). If the clay has a low saturation degree the shearing strength envelopes in both types of triaxial test may be not different for low confining pressures, as shown in figure 5-b.

Considering that the core material, although initially placed with optium moisture, becomes saturated by flow of the reservoir water through the dam, in the SRH Soils Laboratory, triaxial specimens are systematically prepared with the highest possible degree of saturation and the optimum void ratio.

Results of triaxial tests on a highly plastic clay soil used in the construction of Presidente Aleman Dam are shown in figure 5-c. It can be seen that $s$ is practically independent of normal pressure in a Q test, whereas in Qc tests it varies according to a strainght line that forms an angle of 20° with horizontal and cuts the vertical axis at 0.4 kg/cm². Such an envelope, which is quite common for clay soils used in earth dams, is somewhat different from that described at the beginning (figure 5-a), since it does not shown the curve in the interval of low normal pressures, and the straight line does not point to the origin. It is convenient to note that the type of envelope shown in figure 5-a is typical of preconsolidated cohesive soils in their natural state, and is different if the same material is artificially compacted.

In general, failure envelopes given by slow and consolidated-quick tests do not show large differences for compacted soils.

Once the shearing strength envelopes for the two limiting consolidation degrees of a given material are established by the laboratory on the basis of results from Q and Qc tests, it is possible to estimate the values of $s$ for different degrees of consolidation, with some accuracy, if its relationship with water content is taken into account.

### Intermediate Soils

Between sand and cohesive soils, there is a large number of possibilities as a result of a combination of these two with the soil fraction classified as silt. It would be ventured to try to analyze the behavior of the materials in this group, since it is a well-proved fact that small differences in grain size distribution, which have apparently no significance, produce important variations of their mechanical properties.

It is necessary to call the reader's attention on the group constituted by the silty soils, especially when they are either uniform or organic, because of their susceptibility to liquefaction when they are in a loose

**FALCON DAM.—An Earth-fill type dam 160 feet high, 14.1 million cubic yards of volume and 4 million acre-feet capacity. This dam was built on the Bravo river, on the stretch on which the river forms the boundary between Mexico and the United States, and the controlled waters are destined to multiple purposes, principally irrigation and power development for the benefit of both countries. The Falcon dam was built from 1950 to 1953 by the governments of Mexico and the United States, being an example of what can be done through friendship and cooperation between two nations.**

state, and their low resistance to erosion and piping. These soils are difficult to compact, and those having a high content of organic matter are very compressible

The material used in Agostitlan and Santa Ana Acaxochitlan Dams are presented in figure 6 as an example of organic silts. The characteristics of both soils are very similar, namely, void ratios of the order of one, high degrees of saturation for optimum compaction conditions, low plasticity indices as compared with their respective liquid limits, and contraction index larger than 10.

It is considered that the granular structures of organic or uniform silts are unstable. Even when laboratory tests show that such soils have a certain shearing strength, a total collapse (liquefaction) may occur under certain stress conditions. For this reason when analyzing the slopes of a dam, the core of which is to be built of this type of soil, it is assumed that its shearing strength is negligible and the stability of the whole structure is made to depend on the rock shoulders exclusively. This criterion was followed in designing Agostitlan Dam, and its behavior has been satisfactory up to the present. Santa Ana Dam, constructed with a homogeneous earth section has experienced two complete failures in the present century.[8]

### Rock Fills

No tests have been performed to know the shearing strength of rock masses forming the shoulders of an earth dam. It is convenient to remind that in most of the large dams constructed by the SRH, rock shoulders constitute an important part of the section and not a mere protection against wave action.

In rock fragment structures, the shearing strength $s$ is due to friction developed along the points of contact. Extrapolating the results of shearing tests run on gravel and broken stone, it is considered that $s$ varies linearly with effective normal pressures ($s = p_e \tan\psi$).

In the stability analyses of the dams designed by the SRH, values of $\varphi$ varying between 35° and 45° are usually adopted, depending on rock quality, size of fragments, angulosity, and contamination with fine materials. The angle of repose of dumped rock gives a conservative idea of the $\psi$ value, and can be easily observed during construction operations.

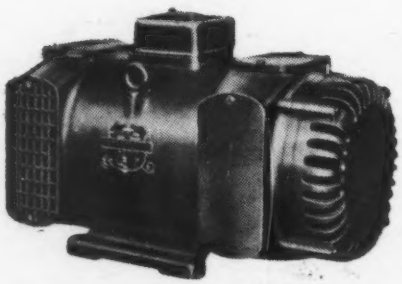
*[To be continued.*

### References

(1). *Diseno Hidraulico de Vertedores en Abanico.* Fernando Hiriart B., ler. Congreso Internacional de Ingenieria Civil en Mexico, 1949,
(2). *Gastos Maximos en la Republica Mexicana.* Publicacion de la Secretaria de Recursos Hidraulicos, Mexico, 1951.
(3). *Presas de Almacenamiento.* Publicacion de la Secretaria de Recursos Hidraulicos, Mexico, 1953.
(4). *Instructivo para Ensayes de Suelos.* Publicacion de la Secretaria de Recursos Hidraulicos, Mexico, 1954.
(5). *Classification and Identification of Soils.* A. Casagrande and R. E. Fadum, Trans. ASCE, 1948
(6). *Phil. Mag. 20,* O. Reynolds, 1885.
(7). *Soil Mechanics in Engineering Practice.* K. Terzaghi and R. B. Peck, Wiley, 1948.
(8). *Earth Dams in Mexico: Design, Construction and Performance.* Raul J. Marsal and Enrique Tamez G., 5th Congress on Large Dams, Paris, 1954.

ROTARY CONVERTERS
*by*
LANCASHIRE DYNAMO AND CRYPTO LTD.

D. C. INPUT
OUTPUTS UP TO 21·5 K. V. A.
A. C. OUTPUT



D. C.-A. C. ROTARY CONVERTER TYPICAL OF SIZES RC4GZ TO RC10W4.
*FOR FULL PARTICULARS PLEASE WRITE TO THE AGENTS*
*for Northern & Eastern India:—*
JESSOP & CO LTD ENGINEERS
63, NETAJI SUBHAS ROAD, — CALCUTTA-1.

# Development of Tunnelling Machines: A Review

By G. S. MARWAHA,
A.I.S.M., C.C.M., M.I.M.in E., M.M.G.I., F.G.M.S., A.M.I.E.
*Government Inspector of Mines*

The driving of tunnels is a problem confronting not only the mining engineer, but also the civil and railway engineers. Tunnels have to be driven in hilly terrains for laying roads and railway tracks, and for diverting the river-waters in connection with river valley projects. In mining, driving of tunnels is a daily affair : the problem varies only with the difference in the hardness and type of starta. In soft strata, driving is done manually with picks, the process being both highly arduous and slow ; and in harder rocks, explosives are made use of. Provision of 'free-face' is a problem, solved in coal and other not-so-hard rocks by using cutting-machines to give a bottom, middle, top or side cut, and in hard rocks by a pattern of 'king' shot-holes. The latest trend in coal mines, however, is to use 'miners' which drive forward into the coal without the help of explosives or 'augers.' (For description, see Appendix A).

The object of this note is to review the development of machines intended for tunnelling into harder rocks. The necessity of such machines arises for achieving increased speeds of tunnelling, a factor which, in view of the high cost of modern projects and consequently the usually high interest charges, is of great importance irrespective of the object of tunnelling. Also the elimination of heavy manual labour of drilling and loading is highly desirable.

## An account of early development

The idea of a machine intended for cutting tunnels is not a new one : engineers have been trying to design such a machine for over a century. As far back as 1851, a machine was constructed and used in driving a tunnel in the USA, and since then attempts have continuously been made either to design new machines or to improve upon existing ones. Though none of these machines met with ultimate success, it is of interest to trace the trend in design.

The early efforts[1] were directed towards cutting a groove to form a core which was later broken down, usually by blasting. The idea was to remove the whole face in a single operation and to eliminate the need to use explosives. Compressed air hammer drills formed the basis of these early designs.

Later on, attempts were made to cut the rock either entirely, or by a series of concentric grooves (relying upon the intervening rock to break down).

A description of some of the early machines designed on the above principles is given in Appendix B.

## Review of later development

The development of rock-tunnelling machines in the major industrial countries during recent times is given below :

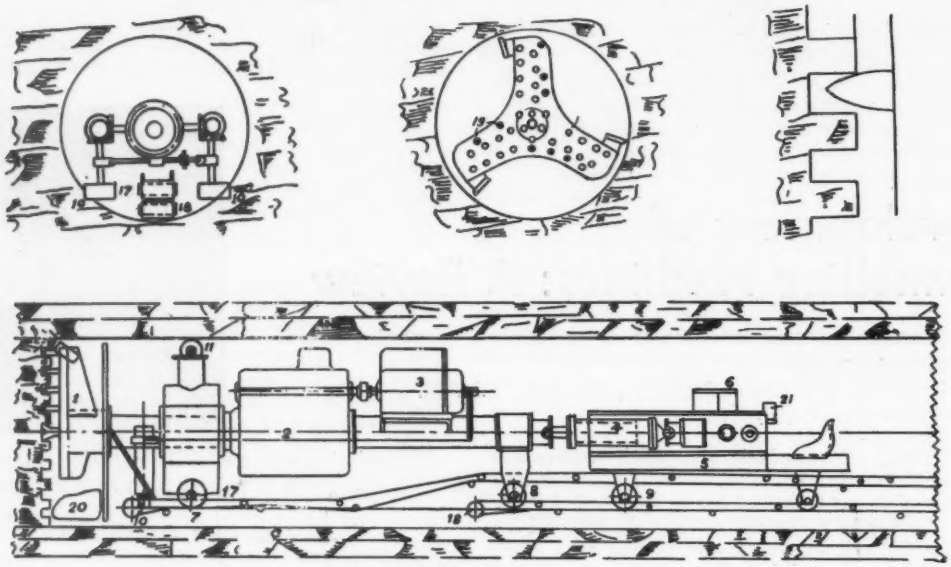
*Development in Germany*[4,5]

A machine was developed by the *Schmidt-Kranz* Company before the Second World War for working inthe Potash mines, where it is working quite successfully. The machine (Figure 1) consists of a cutting head or boring crown, a drive, driving motor, advancing clyinder, conveying carriage and oil pressure power unit. The cutting head, which is driven by the motor through gears, is pushed forward by the oil-pressure-cylinder from the carriage behind. The the cuts made by the cutting head are 1.2 to 1.6 in. wide and about 3 in. deep, and the ribs thus formed are broken off by conical-shaped blades working from the centre outwards. The diameter of the tunnel driven is about 7 ft.

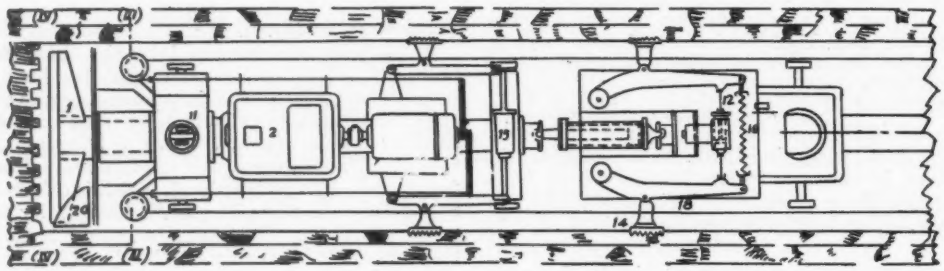
After the war, the *Normag Company of Zorg* improved upon the design for similar use. The machine, which is very large, cuts a tunnel of 9 ft. 10 in. diameter. It is elecrtically driven with a 140 h.p. motor, the cutting being done by a rotary cutting head. The load is applied to the cutters by a central hydraulic cylinder, the thrust being taken by two pads (also operated hydraulically) on the side of the tunnel. The rotary cutter-head cuts grooves in the rock face and then breaks down the rock between the small grooves. The broken rock is conveyor-lifted by buckets attached to the rotating arms of the cutting head, and the whole machine is mounted on wheels running on two tracks formed at the side of the tunnel by two specially designed milling cutters.

In potash, which is relatively soft, speeds up to 6½ ft/hr. can be achieved, and for work in sandstone the Company estimated that a speed of 3 ft./hr. could be expected with a cutter speed of 3 r.p.m. A thrust on the cutters of between 30 and 100 tons would be necessary in sandstone.

Another machine (the *Bade* Tunnelling Machine), originally designed for cutting staple shafts in potash or salt, has also been used for similar purposes in



ELEVATION



PLAN

FIG. 1. SCHMIDT KRANZ ROTARY BORING MACHINE

ironstone mines. When used for this purpose it is pulled up the shaft by means of a rope fed down a previously drilled bore hole and operated from a winch situated in the higher horizon level.

In harder rock, tricone roller cutter-bits are used. These are fitted in sets in the rotating head ; and shafts up to 5 ft. diameter have been drilled. To prevent the machine rotating bodily, two milling cutters cut slots in the side of the shaft into which a section of the frame fits. The load applied by the winch (for potash) is about 10 tons but this is dependent on the hardness of the rock which also determines progress. This varies from 4 in./min. in the softer potash to 1 in./min. in harder rocks.

A machine of this type has been built for trials in staple shaft drivage in coal mines in the Ruhr, and the Company are contemplating design of a machine with a similar design of cutting head for stone drifting. For this work, the machine would be suitably mounted and equipped with means for disposal of the cuttings. The diameter of the tunnel would be about 11½ feet.

*Developments in the U.S.A.*

A machine modified[6] from the original *Mackinlay* coal heading machine was used to drive a 12 ft. $\times$ 7 ft. dipping drift through shales and limestone. Two opposed rotating arms carrying cutter picks break the ground and a coal-cutter chain trims the section left between the arm. The picks initially cut grooves and the intervening rock is dislodged and broken by specially designed breaker rollers. Initially, the arms rotated at a speed of 14 r.p.m. but this was later reduced to 7 r.p.m. A scraper chain collects the broken rock and conveys it for loading to the back of the conveyor.

The machine is powered electrically and is mounted on caterpillars. In the installation referred to above, progress in the hard rock was about 8 in./hr.

Another machine, the *Marietta Miner*, embodying principles similar to the Mackinlay machine, has been successfully applied to driving of drifts in the coal mines of the U.S.A. This machine is described later.

*Developments in the U.S.S.R.*

A machine, the *PDR—1 Machine*, has been desig-

ned specially for drivage in hard rock by the State Planning and Research Institute of the Soviet Union. The cutting element originally consisted of a six-arm star with picks but for harder rocks this was replaced by a different unit carrying 20 or more conical cutter heads.

The machine is powered electrically, and the head is forced into the rock face by a hydraulic arm with a stroke of about 2 ft. operating against a suitable anchoring arrangement. In addition to the cutting head, two further cutters, one on each side of the machine, cut lateral tracks in the circular roadway.

The total length of the unit is 25½ ft. and the height is about 10 ft. It weighs 37 tons and has a total rating of 111kW. The rate of advance is dependent on the hardness of the rock and varies from 18 to 40 in./hr.

*Developments in the U.K.*

A machine built in 1925[7] was used for driving a 15 ft. diameter tunnel in Manchester Red Sandstone. Called the '*Whittaker Machine*', it was mounted on wheels and pushed forward by a central hydraulic ram, the thrust being taken by two feet pressing against the sides of the tunnel. The cutting arms were driven by a 120 h.p. electric motor and revolved at a speed of 3 r.p.m. The exavated sandstone was picked up by collecting buckets fitted to the rotating arms and loaded on to a conveyor. Cast iron cutting-tools were found to be more satisfactory.

The chief difficulty experienced was with the cutters which tended to rub rather than cut the rock due to to insufficient penetrative force. In consequence, the machine had to be stopped frequently for tool changes and progress in the large diameter tunnel was only about 8 in./hr. This machine representated one of the first efforts to use hydraulics ; and it may be that if a smaller diameter tunnel had been selected for initial trials, the difficulty arising from lack of forward thrust would not have been so pronounced.

## Notes on a recent trial[8]

*Description of the Machine*

A USA-made 'Marietta Miner' was tried out in a colliery in Scotland during 1953-55 to form the basis for preliminary work in the development of a machine for stone drifting in the U.K. The machine had 7 ft. diameter cutting arms driven by a 70 h.p. motor through gearing to give 1 rotational speed of 15.6 r.p.m. Each arm was fitted with tungsten-carbide picks disposed to cut an outer, middle, and inner kerf, the cores between the kerfs being broken down by breaker rollers. Propulsion was by caterpillar tracks driven by hydraulic motors with a speed range from 3 in. to 30 ft. per minute, the latter being for flitting.

The weight of the machine was approximately 27 tons, and the forward penetrative force for cutting was dependent on the tractor mounting. Material cut by the cutting tools and broken by the rollers was loaded on to a scraper chain conveyor and delivered to the rear end of the machine. The conveyor was driven by a 15 h.p. hydraulic motor.

*Observations*

The machine was quite effective in cutting coal and softer strata at a high rate of advance, but was found to be incapable of tackling hard sandstone etc.

*Causes of failure*

This failure in harder rock was assigned to the following basic causes :

(a) Apart from the number and arrangement of the picks on the rotationg arms being inadequate and unsuitable, the cutting speed of 345 ft./min. was much too high.

(b) As the forward thrust is dependent on the weight of the machine and the caterpillar tracks, this was limited to about 16 tons. The thrust required for hard rock is in the region of 1 to 2 tons per tool, so the actual specific pressure was only a fraction of that necessary, and little penetration was possible. This factor, allied with the excessive rotational speed, resulted in merely grinding away the tungsten carbide picks. The lack of forward thrust was also indicated with the disc type cutters which were subsequently tried, though even with the limited pressure it was proved that hard rock could be split by using free revolving cutters.

(c) The use of rollers for breaking down the cores between the respective kerfs was unsuccessful. This arrangement, presumably designed to avoid excessive degradation when working in softer coal, is virtually impossible in hard stone since the thrust required is enormous.

(d) The cutting chains as supplied proved to be too light for the work and heavier chains of improved design had to be procured. The lack of thrust also influenced the performance of this unit.

(e) While the use of caterpillar tracks have certain virtues for tramming and manoeuvring, they do not provide sufficient thrust for cutting. In addition, the arrangement, even with a heavy machine, is very unstable.

## General analysis of the problem

The problem of a machine for stone drifting is essentially one of cutting the harder strata, as machines are already available that can successfully function in coal and softer rocks.

From an analysis of the experinence gained so far, it is considered doubtful if partial coring, using picks, is the answer to hard-rock cutting. Apart from the difficulty in balancing the load on the cutters spaced along a radial arm, difficulty is likely to arise in really hard material in breaking down the intervening cores. It may, therefore, be necessary to literally break down the whole face by using a combination of disc-cutters rotating in an orbit on somewhat similar lines to the Bade staple shaft machine. In fact, this is what the Bade Company proposed in a provisional adaptation of their machine for stone drift work, and it would be noted that the Russian machine head also uses a form of rotary cutter. In America, the trend is also towards improved balance and in the later type of machines three, instead of two, cutter arms are used.

Excessive breakage of the rock may present difficulties in loading, particularly as a large quantity of water may be required for dust suppression and some form of hydraulic fluming or conveying may have to be

considered as in the Sigafoos machine described in Appendix B.

Further, it is desirable that the speed and feed of the cutting unit be controlled within the limits required by the material being driven through. This can best be accomplished by the extended use of hydraulics, which would provide a more positive and effective thrust and allow variation in cutting speeds according to the type of rock being cut. The failure of the Marietta in harder rock could be traced to excessive cutting speed and insufficient thrust, and it should be noted that in the Whittaker machine, designed over 30 years ago, the speed was only 3 r.p.m. This speed also corresponds with that suggested by the designers of the Schmidt-Kranz machine for operation in sandstone.

It has been estimated that for positive drivage in hard sandstone, driving power in the region of 150 h.p. and a total thrust up to 200 tons—varying according to the hardness of the rock—should be provided. A great deal has yet to be learned about rock pressure resistance and specific pressures required for penetration, and there is a wide field for research on this subject. But, provided the cutting is done at the correct speed and thrust, it is thought that a tool life of 50 to 60 hrs. uninterrupted working in hard rock, with a corresponding increase in softer rocks, could be reached. This should result, with a minimum progress of 1 in./min. (which it is suggested should be the aim) in about 300 ft. of roadway drivage without changing cutters.

### Observations

The increase in the speed of tunnelling obtained by improving the existing drilling-shotfiring-and -loading practices has reached its limits; and further advances in this direction can be expected only from a basic change in the operations of tunnelling. The idea of driving tunnels by machines, resulting in the elimination of the separate operations of drilling, blasting and loading, is considered to be sound and with prospects of further development—especially when the obstacles of lack of suitable hard metals, and of applying power through hydraulic and other means have been largely overcome by advances in in their respective spheres.

## APPENDIX A

### A Description of Coal-Heading Machines

The earliest investigations[1] into the possibility of dirvage in coal were made by Stanley of Nuneaton, U.K. His machine was essentially a coring machine, the earlier version varying one cross-arm with picks which cut a circular groove leaving a solid block of coal in the centre of the heading. Later a machine with two cutters was tried, with the dual object of cutting a wider place and breaking down the coal.

Recent development of coal-heading machines has taken place mostly in the USA during the post-World War II period ; and several machines are now in use in that country for driving galleries in coal. Some prototypes are also being tried out in the coal mines of UK. Two distinctly different ideas have been developed : those of pick-cutting and of drilling. Following is the description, under these two heads, of the machines now in commercial production.

(*a*) The 'Continuous Miner' or the 'Colmol' heading machines developed in the USA in the immediate post-World War II period and now manufactured by several companies, are in extensive use in that country. A typical[9] *Continuous Miner* (manufactured by the Joy Company) weighs approximately 15 tons, is 25 ft. long × 7 ft. wide × 2 ft. 10 in. high ; and is composed of three principal parts :

(*i*) Turntable mounted on capterpillars ; from which is swing the
(*ii*) Ripper-bar or cutting element ;
(*iii*) Discharge boom conveyor.

The ripper-bar, which also functions as the loading head, comprises six standard cutter-chains (Figure 2) running vertically to the coal seam. Each

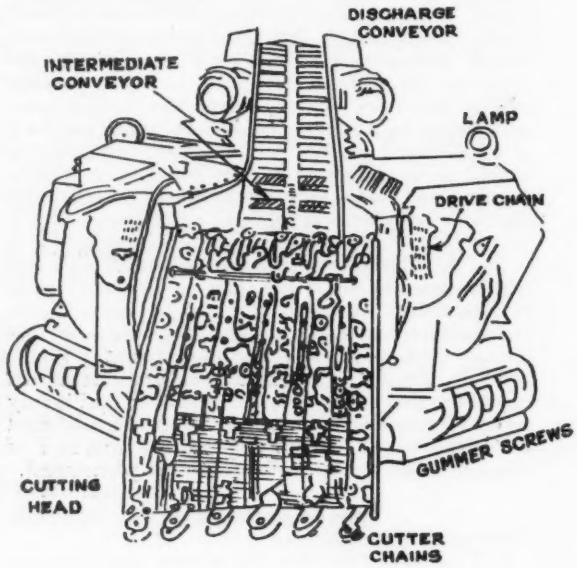



FIG. 2. JOY CONTINUOUS MINER

chain carries 20 carbide-tipped bits and runs at a speed of 500 ft./min. The overall width of the ripper-bar is 30 in, and it is capable of an 18-in. forward movement without the main chasis moving in its caterpillars. It has a vertical shear of 5 ft. 4 in. ; and the horizontal swing is 16 ft. from rib to rib. These movements are achieved hydraulically, except for the cutter-chains, which are driven by two 65 h.p. motors.

The Miner carries two conveyors, an intermediate one immediately behind the ripper-bar delivering coal into a small hopper, and a discharge-conveyor from the hopper to the back-end of the machine. This latter conveyor can be swung 45° right or left to allow cornering. The Miner sumps in at the bottom and works upwards, breaking and loading the coal.

In a new type, manufactured by the Joy Company, the series of continuous chains in the mining head have been done way with, and all but two of these have been replaced by circular cutting discs. The Jeffery Colmol Machine (Figure 3) also works on a similar principle.[10]

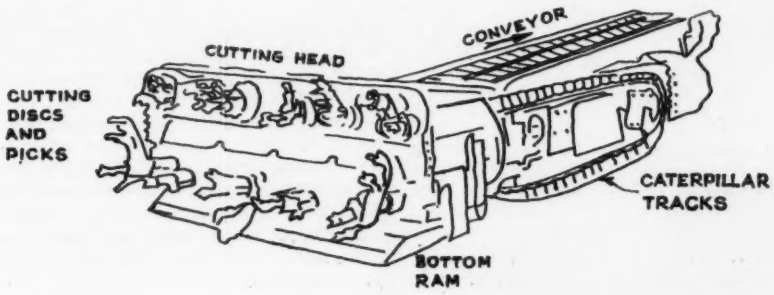



FIG. 3. THE JEFFREY COLMOL MACHINE

In the machine manufactured by the *Goodman* Company, the cutting head is 3½ft. wide and cuts downwards in the reverse direction.

The 'Kolmaster' designed by *Lee Norse Company* has two cutter-heads with the cutting discs set at a special angle. Galleries, upon 16 ft. wide and 6 ft. high have been driven with these machines.

lowered hydraulically by means of jacks between roof and floor, similar control being used for feed and retraction.

*Joy Underground Auger Drill* (Figure 4)

The driving unit consists basically of a steel frame on which is mounted a 40 h.p. motor and control. The auger is rotated mechanically through a clutch

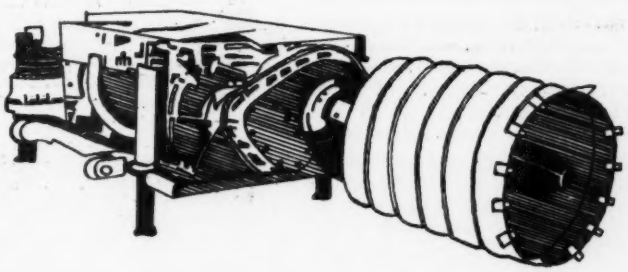


FIG. 4. JOY-SULLIVAN AUGER DRILL

*The Bituminuous Coal Research Inc.*

Has been working on a mining head or rotor with one or more arms which cut a circular groove. This groove allows expansion space for the action of a large wood screw which wedges off the coal as the machine advances. The arms are controlled by the operator who can vary the diameter according to the nature of the coal being mined.

(*b*) The *Coal Auger* operates on a principle similar to that of small-diameter drills. The augers used in open workings are upto 6 ft. in diamter. Two manufacturers have developed machines for underground use in coal mines.[11]

*Cardox-Hardsocg Auger Miner*

The Machine has overall dimensions of 24 in. height ×10½ ft. length × 6 ft. in width; and is designed for handling auger sections upto 30 in. in diameter and 6 ft. length. It is powered by a 25 h.p. motor which drives the auger through a fluid coupling, dry-plate clutch, and a reversing and final gearbox whose output shaft has an auger chuck on each end to provide two-way operation. The machine is elevated and

and gearing. The motive power for the ram, winches and hydraulic jacks is hydraulic. The overall dimensions are 9 ft. long × 5 ft. wide × 2 ft. 6 in. high; and the weight is approximately 4½ tons.

In both types, standard auger-sections are used, consisting of a spiral made from mild steel plate about 3/8 in. thick continuously welded to a central tube. The sections are withdrawn from holes by means of a rope and hydraulic winch. A typical auger-head[12] is shown in Figure 5.

## APPENDIX B

### A description of a few of the early Rock-tunnelling Machines[1 2 3]

(*a*) *Proctor-Tunnelling Machine*

This was a typical example of the application of

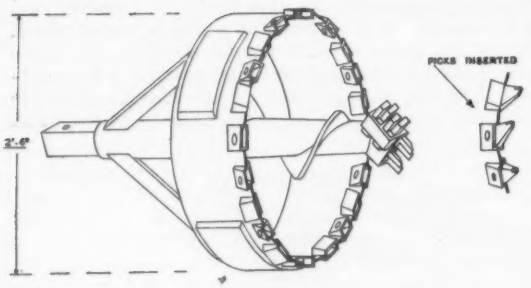



FIG. 5. A TYPICAL AUGER DRILLING HEAD

conventional drilling. The cutting head, which consisted of four arms, each carrying four hammer drills, revolved at about one r.p.m. The drills were so disposed that the complete face was covered by one complete rotation of the head, air being supplied through a hollow supporting shaft. A cylindrical shield surrounded the head, and provision was made for raising the cuttings from the floor where they were discharged through a hole in the back into a hopper which in turn fed on to a conveyor. The machine was built on a mounted frame and the feed was by means of a rack-rail. The weight for an 8 ft. diameter tunnel was 15 tons ; and the general dimensions were 27 ft. long × 6 ft. wide × 5 ft. high.

(*b*) *Sigafoos Machine*

This machine also had a percussive action, but on somewhat different lines since electric power was used. It consisted essentially of a number of cutting or crushing heads which operated similar to a stamp battery, except that the blow was struck by a spring instead of by the force of gravity. An interesting feature was that the whole machine revolved during cutting, rolling on "foot wheels," the axles of which were so arranged that they could be pre-set so that the wheels did not track, but described a helical path, thus moving the machine forward at any desired speed. Reliance was placed on the weight of the mamachine (20 tons) to keep it up to its work, and the cuttings were removed from the tunnel hydraulically either by fluming or by pipe line.

(*c*) *Brunton's Tunnelling Machine*

This is typical of several machines designed during the latter part of the last century when engineers were considering the drivage of a tunnel under the English Channel. The first of these is generally known as the *Beaumont* machine and was actually used for drivages in chalk where rates varying from 50 ft. to 80 ft. per day were achieved. A somewhat similar machine was developed by *Brinton* and while this machine, like the Beaumont, was designed primarily for cutting in the chalk formations, it is of interest in so far as it is the first instance of the use of disc or rotary cutters. The cutters were circular in shape, and had a rolling motion when in action. Under pressure, the sharp wheels caused the rock to spring off in the form of spawls. The action is therefore not one of cutting, nor it is percussive, being more aptly described as persistent wedging and therefore dependent to a large extent on the penetrative pressure available. The cuttings were picked by the rotating head and delivered to the rear of the machine by a conveyor belt.

A Brunton machine was actually used on both sides of the Channel where it drilled at aggregate of approximately 8,000 ft. of 7 ft. tunnel, the rate being about 30 in./hr. Later, several thousand feet of tunnel in somewhat harder tock was also driven, but further development appears to have ceased on the death of the inventor.

**References**

1. "Mining" by Lupton ; pp. 307-311.
2. "Tunnelling" by Drinker ; pp. 191-194.
3. Proc. Chesterfield and Derbyshire Engr 2nd Oct. 1875.
4. Technical Report on Ruhr Coalfield ; Vol. 3 ; Appendix 13a, 1946.
5. Pilzer, A.,"The Development of Roadway Heading Machine," Gluckauf, Vol. 90 ; No. 51/52, pp. 1648.
6. Mining Congress Journal, May 1951
7. "Whitaker Machine," British Patent No. 254, 839, 1926.
8. Wilson, H. H., "Notes on Rock Tunnelling Machines," read before the Mining Institute of Scotland, 1955.
9. Bennett, H. B., "The Development of Continuous Mining at Donisthorpe Colliery," T.I.Mine., Vol. 111, pp. 174-195.
10. Greensmith, J.V., 'Some Aspects of American Coal-Mining Practices," T.I.Min.E., Vol. 111 pp. 795-806.
11. Wilson, H.H., "Coal Augers : Development and Application Underground," T.I.Min. E., Vol. 113 pp. 524-539.
12. Young, M.H., "Ventilated Auger Mining at Hucknall Colliery," T.I.Min.E., Vol. 114, pp. 337-365.

*Continued from page* 23

## Kariba Hydro Electric Project

It will also encourage a greater output of copper, more electric smelting of copper, an expansion of ferrochrome output, and the probable introduction of a much-needed nitrogen fertiliser plant.

### No Major Difficulties

Experts believe that the site of the dam is excellent from the construction viewpoint, and no major difficulties are anticipated. In December, exceptionally heavy rains did strand the pioneer construction teams at Kariba, but that sort of incident is one of the ordinary hazards of such projects. It did not prevent the engineers from completing the foundations of the coffer dam and raising the dam wall sufficiently to enable the first stage of construction to be carried through.

Contractors from all over the world have submitted tenders. Already one contract, valued at about $3,500,000 has been awarded to Richard Costain (Africa) Ltd.—which is an offshoot of the British firm—for the building of a township to house workers, and work has started.

Very careful plans are being made in both Northern and Southern Rhodesia to provide for the resettlement of Africans living on both sides of the Zambesi whose present homes will be flooded by the lake behind the dam.

Quite certainly, the advent of Kariba power will herald another great forward leap in the development of area already expanding as rapidly as any in the world. The Zambesi, which David Livingstone saw as a great waterway opening up Central Africa to civilisation, is about to play just that role, though hardly in the way he anticipated.

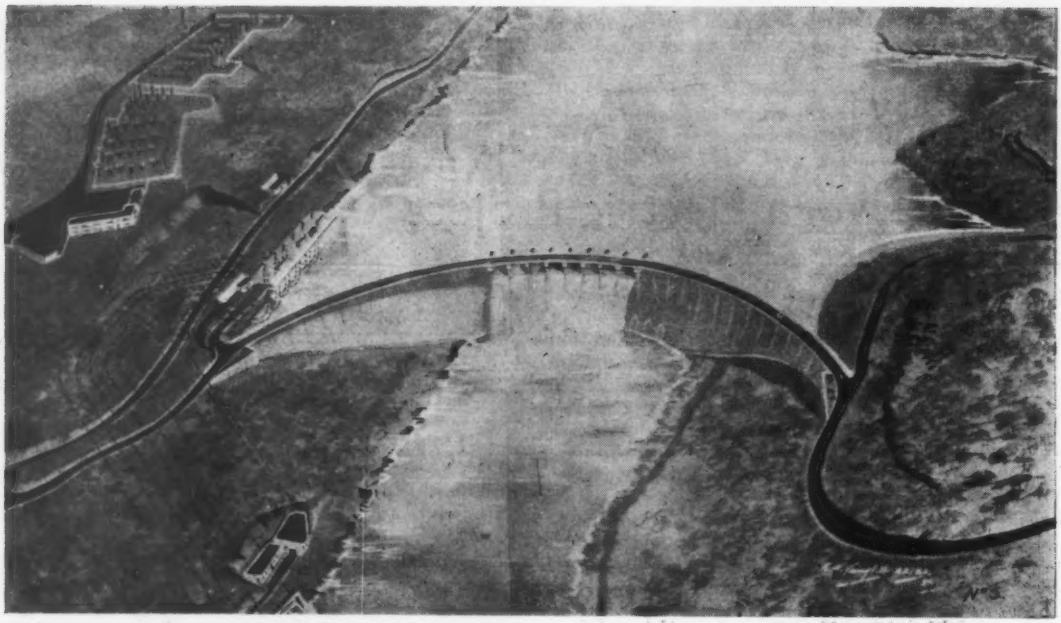
# Kariba Hydro Electric Project

By DON TAYLOR

A major reason for the inception of the Federation of Rhodesia and Nyasaland was that the British Government of the day believed that a new act of faith in the realm of racial partnership was urgently needed in Central Africa. Lord Chandos, who as Mr. Oliver Lyttelton was the Secretary of State for the Colonies at that time, emphasised this frequently. But, at the same time, it was generally recognised that Federation would bring considerable economic advantages to all three territories—the two Rhodesias and Nyasaland since their economies were largely complementary ; and it has been the firm conviction of the Prime Minister of the Federation, Lord Malvern and of his deputy, Sir Roy Welensky, that partnership itself could only be established on the basis of a prosperous economy.

**KARIBA HYDRO-ELECTRIC SCHEME—FEDERATION OF RHODESIA & NYASALAND**
**The Kariba gorge on the Zambezi River, showing view upstream.**

**KARIBA HYDRO-ELECTRIC SCHEME—FEDERATION OF RHODESIA & NYASALAND.**
**An artist's impression of how the dam will look in 1958. The Zambezi is bounded by Southern Rhodesia (left of drawing) and Northern Rhodesia (right of drawing). On the left can be seen the underground power house which will eventually house six terbogenerators and transformer units. In 1958 two units will be completed with intakes and tail races. Work will also be in progress on the switching station and control house (left).**
**(By courtesy : Optima Quarterly**



**KARIBA HYDRO-ELECTRIC SCHEME—FEDERATION OF RHODESIA & NYASALAND**
**An artist's impression of the completed dam overflowing. All six turbine tail races and intakes are shown by dotted lines. The road from Salisbury crosses the top of the dam wall, leaving the diagram at the bottom right hand side en route to Lusaka. The completed dam wall is 400 feet high from the river bed to the roadway. The total effective length of the spillway is 306 feet, divided into eight sections, each with a gate 3′ long and 26 feet high.**
**[By courtesy : Optima Quarterly.**

Now to ensure that prosperous economy, it has been necessary to seek diversification. Agriculture and mining, the main industries in Central Africa, were—and are—capable of considerable expansion. But a rapid increase in secondary industries was essential. Industrialisation demands cheap power ; indeed, it is the first requisite demanded by the outside manufacturer seeking to start up production in any territory. And quite apart from power being needed for secondary industry in the Frederation, it was urgently needed by Northern Rhodesia' copper mines.

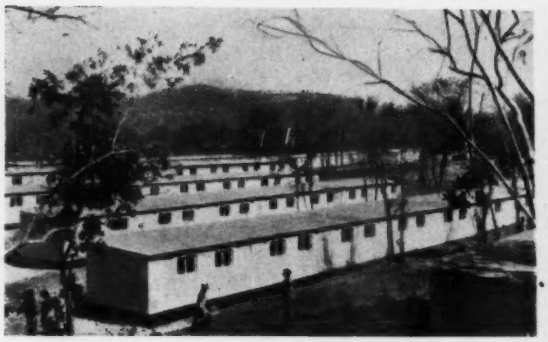
**KARIBA HYDRO-ELECTRIC SCHEME—FEDERATION OF RHODESIA & NYASALAND**
**Excavations for coffer dam on the South bank.**

### Impressive Potential

All three territories of the Federation have an impressive hydro-electric potential. Nayasaland with the Shire River, Northern Rhodesia with the Kafue River, Southern Rhodesia with the Zambesi River at Kariba Gorge. After exhaustive and expert investigation, it was decided last year to give priority to Kariba. Monsieur Andre Coyne, one of the world's greatest experts, who made the final appraisal, has said 'Kariba power will be the cheapest in the world for regulated energy.'' He added that the vast storage capacity (the reservoir will take three seasons to fill) will give valuable support to any other scheme subsequently developed in the Zambesi basin.

What of the cost of this ambitious project—this economic buttress for racial partnership ? Recently during a debate in the Federal Parliament, the Minister of Power, Sir Malcolm Barrow, revealed that the cost of initial development is now estimated at $79,414,000, though the cost of ultimate development will be $113,234,000. Firm annual output will be 7,650 million kilowatt hours, while cost per unit will, it is calculated, range from .869 pence in 1961 to .283 pence in 1972.

The copper mines of Northern Rhodesia should get power from Kariba by 1960, while Southern Rhodesia will get it by 1961.



**AFRICAN HOUSING AT KARIBA (BACHELOR QUARTERS).**
**Every worker (and wife) has a 2′ 6″ sprung bed and a combined steel locker and table. Bachelors eat in communal dining rooms. Families are supplied with tables and chairs and have individual cooking facilities.**

**KARIBA.—Road bridge under construction over the Zambesi.**

## Work Started

A total of 150,000 tons of materials and equipment will have to be carried by rail to Kariba, and two new marshalling yards are to be established to cope with this vast operation. Already the Federal Hydro-Electric Board has issued contracts for the housing site and access roads, and called for others for laying railway lines and roads, and building storage sheds. Work has already started.

Who will provide the money? Lord Malvern has already pointed out that if the finance was obtained from sources other than the London market, it would not impede raising funds in that market for the Federation's general development programme.

The International Bank for Reconstruction and Development has already approved a loan of $28,600,000, in various currencies, for the first stage of the Kariba scheme, and the Colonial Development Corporation and the Commonwealth Finance Company are two other parties which may ontribute towards it financing. The Copper Mining Companies of the Rhodesian Selection Trust Group, in conjunction with those of the Anglo-American Group, have already decided to lend $20,000,000 to the Federal Government, and to accept a surcharge on electrical energy supplied for Kariba from 1961 to 1967, which will total $10,000,000. A large proportion of this $30,000,000 from the mining companies will be used for Kariba.

Further loans for Kariba have also come forward from Barclays Bank D.C.O. ($2,000,000), the British South Africa Company ($4,000,000) and the Standard Bank of South Africa ($2,000,000).

An expansion of manufacturing industries will be a major result of the availability of cheap power.

**KARIBA HYDRO-ELECTRIC SCHEME—FEDERATION OF RHODESIA & NYASALAND.**
**Work in progress on the north bank, Kariba.**

*Continued on page* 20

# All India Power Engineer's Conference Bangalore 1957

## RESOLUTIONS ADOPTED

*Resolution No.* 1

**Investigation of Hydro-Electric Schemes**

The demand for power is increasing rapidly. If this demand is to be met satisfactorily, it appears that the generating capacity in the country will have to be doubled every five years or so for the next three Five-Year Plans at least. The programme for addition to the generating capacity during the 2nd Five Year Plan provides for the installation of hydro-electric plant to the extent of 2.2 million kW. The third Five Year Plan envisages the establishment of additional generating capacity of 8.0 million kW. It is estimated that the hydro component of the additional capacity to be established will be of the order of 6 million kW. This trend of development definietely indicates that detailed investigations should be started right now for ensuring that there is a sufficient number of projects ready for inclusion in the third Fiver Year Plan. With this objective in view, at the time the second Five Year Plan was formulated, the Working Group provided certain amounts of moneys for investigation of projects in the plans of every State. The Conference views with concern the tendency on the part of some State Governments to divert these funds for other projects. It further emphasizes the need for accelerated pace of investigation of hydro electric schemes in larger number so that it would be possible to fix priorities and select the most economical schemes for execution during the Third Five Year Plan period. It urges every Chief Electrical Engineer of the State to bring to notice of the respective Governments the need for the immediate commencement of investigation of schemes and for the establishment of a suitable organisational set up headed by an officer of the status of a Superintending Engineer for this purpose.

*Resolution No.* 2

**Administration of Projects**

The Conference wishes to place on record its satisfaction on the announcemtnt made that all the States would establish State Electricity Boards in accordance with the Electricity (Supply) Act, 1948, and hopes that with the establishment of the Boards, many of the administrative difficulties now encountered would be overcome.

With regard to the construction of River Valley Projects, the Conference views with concern the various types of organisations that are being set up, bringing in their wake certain difficulties in the expeditious implementation of the schemes. It therefore endorses the resolutions passed at the Fourth Engineers' Seminar held at Hirakud, as follows :—

"It was agreed that the Control Board is a suitable form of organisation for the execution of River valley Projects. In the case of multi-purpose projects, the Chief Engineer for Power who is often to secure decisions of the Control Board and has also to contribute to the decision-making process in the Control Board should also be a Member of the Control Board along with the Chief Engineer for Irrigation."

"Where the decision-making process and the staff are predominently technical, the head of the organisation should be a technical person experienced in organisation. He should be assisted with administrative personnel for performing adminstrative functions. Where however the adminstrative functions, e.g. rehabilitation of displaced persons, etc., is of a size and complexity demanding a high level administrator, the Chief Engineer and the Administrator should function as colleagues serving a common aim.

"The responsibilities of and the delegation of powers to the General Manager, Bhakra Dam, should be regarded as a model, to be adjusted to suit local conditions.

"A Chief Accounts Officer responsible to the Chief Engineer should be provided for maintenance of of accounts and for giving internal financial advice to the Chief Engineer.

"The Secretary of the Control Board should preferably be a whole-time person and appointed with the concurrence of the Board."

*Resolution No.* 3

**Procurement of equipment and materials**

This Conference views with concern the delays occuring in the procurement of equipment and materials required for execution of power projects. It appreciates that some of these delays occur due to want of forward planning. The need for coordinating the requirements of power supply industry with the available indigenous manufacturing capacity is established. The note circulated by the Central Water and Power Commission on 'Procurement of equipment and materials with indigenous angle' and the clarification thereof furnished by the General Reporter as well as the Industrial Adviser to the Ministry of Commerce & Industry are noted. The Conference generally endorses the procedure suggested in the note referred to above and considers it necessary to evolve a a practicable procedure that would be acceptable to the power supply industry, the Development Wing of the Ministries of Commerce & Heavy Industries and D.G.S. & D. It therefore recommends the appointment of a committee consisting of the following persons to examine this question in detail and submit its recommendations to the Ministry of Irrigation and Power for implementation.

1. Dr. B. D. Kalelkar, Industrial Adviser (Engg). Ministry of Heavy Industries.
2. Shri K. C. Gupta, General Manager, K.E.S.A.

3. Shri P. A. Krishnan, Superintending Engineer (Technical), Madras Electricity Department.
4. Dr. M. Datta, Superintending Engineer, West Bengal State Electricity Board.
5. Mr. M. Hayath, Member, C.W.& P.C.
6. Mr. S. S. Kumar, Member, C.W. & P.C.
7. Mr. H.V. Narayan Rao, S.E., Mysore Electrical Department.
8. Mr. V. Pappu, S.E., Andhra Electrical Department

This Conference further proposes the appointment of a Committee consisting of the following members for standardising the specifications for distribution transformers, etc., which is pre-requisite for adoption of the procurement procedure suggested above.

1. Shri S. G. Nadkarni, Elecrical Engineer, Bombay Electricity Board.
2. Shri K. M. Chinnappa, Additional Chief Engineer, Damodar Valley Corporation.
3. Shri T. N. Idnani, Chairman, D.S.E.B.
4. Shri V. Pappu, Supdtg. Engineer (Electrical), Andhra Electricity Department.
5. Shri J. P. Mehrotra, Dy. Director (Engg). Indian Standards Institution.
6. Shri M. Hayath, Member, C.W. & P.C.
7. Shri S. S. Kumar, Member, C.W. & P.C.
8. Shri P. A. Krishnan, S.E., (Technical), Madras Electrical Department.
9. Shri N. N. Chakravarty C.E.E., U.P.
10. Shri G. Sambasivaiah, E.S., Mysore, Electricity Department.

The procurement procedure proposed to be followed would be in respect of the following items for the present.

(*a*) Distribution transformers;
(*b*) Conductors;
(*c*) Insulators;
(*d*) House service Meters.

*Resoluton No.* 4:

**Economy in the use of materials in short supply**

This Conference views with concern the shortage of steel and cement that is being experienced by the various project authorities and the consequent delay in the execution of projects. In order to reduce the use of quantity of steel and cement that is being experienced by the various project authorities and the consequent delay in the execution of projects. In order to reduce the use of quantity of steel and cement in projects to the minimum practicable, it recommends the appointment of a committee of following members to investigate and to recommend ways and means for effecting maximum economy in the use of cement and steel:—

1. A representative of the Federation of Electric Supply Undertakings.
2. Shri A. R. Narayana Rao, Chief Operating Engineer, Madras Electricity Department.
3. Shri J. L. D'Sa, Chief Engineer (Electricity), Government of Mysore.
4. Shri K.S. Sivaprakasam, Superintending Engineer Chambal Project.
5. Shri P.V.A. Narayanamurthy, Dy. Chief Elec. Engineer, D. V. S.
6. A representative from the Office of the Iron and Steel Controller.
7. Shri M. Hayath, Member, C. W. & P. C.
8. Shri S.S.Kumar, Member, C. W. & P. C.

*Resolution No.* 5:

**Coordination of Hydro and Thermal resources**

This Conference notes with satisfaction the work done by th Central Water and Power Commission in the field of survey of hydro-electric potential of the country. In as much as a coordinated development of hydro and thermal power is essential for securing optimum benefit from the available resources, it recommends that the Central Water and Power Commission should undertake survey of thermal resources simultaneously with survey of the hydro-electric resources and indicate not only the resources available but also suggest the locations of the thermal stations.

*Resolution No.* 6

**Power Development on Zonal Basis**

This Conference recognises that Power Development Programme should be planned on a zonal basis to secure the optimum utilisation of the resources of the area and the zones as laid down in the S.R.C. Act. Increase in the generating capacity in the zone should be closely coordinated with its utilisation so that the time interval between the establishment of generating capacity and its utilisation is made the shortest possible. This Conference deems it necessary to set up a Technical Committee in each zone to accomplish the above objective ; the Technical Committee to consist of :—

(1) A representative of the C.W.P.C
(2) A representative of the Ministry of Commerce and Industry (Development Wing).
(3) The Chief Electrical Engineers of concerned States and/or Boards, Statutory Corporations in the zone.
(4) Technical Representatives of the Development Commissioners of the States concerned.
(5) A representative of the Federation of the Electricity Undertakings.

It may be noted that the above recommendation is in consonance with the decisions arrived at the 3rd Engineers' Seminar held at Srinagar during July 1956.

*Resolution No.* 7

**Training of Technical Personnel**

This Conference recognises the necessity and importance of field training for different categories of technical personnel. It, therefore, recommends that a committee consisting of the following members be appointed to examine this question and make appropriate recommendations :—

1. Shri Advani.
2. Shri G. K. Ambady (Ministry of Railways).
3. Major Lochan Singh (P & T).
4. Shri Chandarkant (Ministry of Education).
5. Dr. S. P. Luthra (Delhi Polytchnic).
6. Shri N. J. Balani (Boards).
7. Shri Mathur (State Government—U.P.).
8. Representative of the F.E.U.
9. Shri Narayana Rao.
10. } Members of the C.W. & P.C. (P.W.).
11. }

*Resolution No.* 8

**Uniform System of Accounting**

This Conference recognises the urgent need for a uniform practice in the preparation of accounts for

presentation in the forms prescribed by the Indian Electricity Rules, 1956, and audit thereof. It, therefore, recommends that the Central Electricity Authority should arrange for the early preparation and issue of a code for the said purpose.

*Resolution No.* 9

**Rural Electrification—I**

This Conference recognises that financing of rural electrification cannot be subjected to the normal financial justification. A study of the rural electrification all over the world reveals that a subsidy in some form or other is essential if extensive rural electrification is to be accomplished. This Conference notes with satisfaction that a high level Study Group set up by the Ministry of Irrigation & Power has this question under study. It wishes to bring to the notice of this Study Group and through it to the Government of India that it is essential that an early decision is taken in this behalf. This Conference endorses the decisions arrived at the Second Engineers' Seminar at Roorkee and that any grant of subsidy shall be subject to prior utilisation of all surplus revenues of the State Electric Supply Industry by the States and/or Boards to meet the deficits caused by the extension of rural electrification.

It further recommends that the Departments of Industries and Commerce of the State Governments and the Union Ministry connected with development of cottage, small scale and light industries should be be requested to disperse the location of these industries into the rural areas, so that apart from securing other benefits, it may contribute towards development of load in rural areas to make rural electrification self-sufficient within the shortest period practicable.

*Resolution No.* 10

**Rural Electrification—II**

This Conference recognises the need for accelerated rural electrification. As the rural loads are few and far between and the individual loads are small and generally have low load factor, the cost of electrification will have to be reduced to the minimum practicable if the initial financial loss to be incurred in rural electrification is to be reduced to a minimum. Even though recently the Electricity Rules were revised and issued as Electricity Rules 1956, it is felt that further relaxation in respect of certain provisions of the Rules in construction of rural lines below 33 kV, would be in the interest of economy without materially sacrificing efficiency and safety. It therefore recommends the appointment of a committee consisting of the following members to go into the question and recommend the relaxation from the provisions of the Rules.

*Committee*

1. Shri P. A. Krishnan (Madras).
2. Shri K. P. S. Nair (Kerala).
3. Shri J. L. D'Sa (Mysore).
4. Shri G. P. Mathur (U.P.).
5. Shri Lachman Singh (Punjab).
6. Shri S. G. Nadkarni (Bombay).
7. Shri S. S. Kumar (C.W.P.C.).
8. Shri M. Hayath (C.W.P.C.).
9. A Representative of the F.E.U.

This Conference further recommends that after the recommendations of the above Committee are accepted by the States, the Central Water & Power Commission may arrange to evolve suitable standard designs for various items of work in consultation with the Chief Electrical Engineers of the States and/or Boards and the Federation of Electricity Undertakings.

*Resolution No.* 11

**Rural Electrification—III**

This Conference notes with satisfaction the importance attached to Rural Electrification. It recommends that special sections in the State Electicity Departments should be formed wherever they have not been formed so far in order to have a closer study of the problems involved and accelerate the progress in this direction.

*Resolution No.* 12

**Wood Poles**

This Conference notes with satisfaction that the Central Board of Forestry at its meeting in Srinagar in June 1956 have expressed that it may be possible for the forest departments to supply all the requirements of wood poles for the electricity schemes from the Indian forests. It also notes that the formation of a Central Board of Wood Poles was recommended and this has been accepted by the Ministry of Agriculture for purposes of procurement of the poles and distribution. This Conference requests this Central Board of Wood Poles to consider ways and means of obtaining treated wood poles to meet the requirements of the electricity schemes urgently.

This Conference also notes with satisfaction that several tests are being conducted by the Forest Research Institute, Dehra Dun, in consultation with the Central Water & Power Commission on various types of wood poles with a view to liberalise the factors of safety.

*Resolution No.* 13

**D.C./A.C. Conversion**

This Conference views with concern the considerable delay which is occurring in the conversion of D.C. supply systems in the various areas in the country to A.C. While the difficulties encountered in the conversion are appreciated, it is felt that the accomplishment is far behind anticipations. Even though specifying of a general target date for the country as a whole is not considered desirable, this Conference forcefully urges the undertaking still having D.C. supply in their systems to set a target date for themselves and put forth the maximum efforts to achieve the same. In order to enable the Central Water & Power Commission to assess the achievements in this direction, the undertakings concerned should arrange to furnish the progress achieved at the end of each financial year, with details of the programme contemplated for the subsequent year along with financial implications.

*Resolution No.* 14

**Impulse Testing Transformers**

This Conference views with concern the tendency on the part of some of the State Electricity undertakings to specify impulse test for each transformer purchased, and also considerable variation in the insulation levels. In view of the possibility of the damage that may occur during impulse tests, it is

*Continued on page* 32

# Euclid TC-12

### Each Crawler Track Independently Powered

The most unusual feature of the EUCLID Crawler Tractor is that each crawler track is powered independently and the unit uses two General Motors series 71 engines. The engines are full diesel engines utilising the two-stroke principle of operation. Full diesel means that no external devices are used to fire the fuel, such as an electric spark system, etc. In these engines, air alone is compressed in the cylinder ; then, a charge of fuel is sprayed into the combustion chamber, after the air has been compressed, ignition is accomplished by heat of compression. The two cycle principle means that air and exhausting of burned gases takes place during part of the compression and power strokes, respectively.

The engine is of the valve-in-head type, featuring a fully counter-balanced crankshaft and replaceable cylinder liners for ease of maintenance. Hand hole cover plates on the cylinder blocks facilitate the inspection of liner ports, cylinders and pistons.

### Separate Frame Assemblies

Each diesel engine is mounted into a separate frame assembly. Each frame is basically identical in construction. The main frame consists of two welded, box section rails, joined at the front by a heavy steel plate and reinforced in the mid section by the stabilizer member and at the rear by the pivot shaft housing. The frame rails are joined at the rear by a fabricated drive case which serves as a mounting base for the transmission. This is also an oil reservoir for the transmission operating oil.

The two halves of the tractor being separate are connected by a transverse pivot shaft, and oscillation guide which allows the two main frames to oscillate with respect to one another, thus ensuring maximum crawler show contact on undulating ground.

### Crawler Track Assembly Has Special Features

Two crawler track assemblies are attached to their individual main frames at two places—the pivot shaft housing and the stabilizer. The pivot shaft housing is bolted to the rear of the crawler roller frame, and the stabilizer is bolted to the middle of the crawler roller frame. The stabilizer and the pivot shaft keep the crawler roller frame in alignment with the main frame. The track rollers support the entire weight of the tractor on the track chain. They are forged steel rollers mounted in taper bearings and these rollers are mounted on the under-side of the roller frame in special semi-circular grooves machined in the roller frame rails.

The front track idler wheel supports the track chain at the forward end of the roller frame. It is mounted between the roller frame rails and it is designed to slide on the rails, allowing it not only to support the track chain, but to maintain track tension as well.

Track tension is controlled by the pressure maintained in a grease filled recoil cylinder and nitrogen charged accumulator. When a shock load is placed on the front idler, it slides rearward, retracting the recoil cylinder piston rod. This transfers the shock to the recoil cylinder piston and the grease behind the piston. The grease, displaced by the shock, is forced against the piston in the accumulator, which in moving to absorb the shock, further compresses the charge of gas in the accumulator. Track tension can be varied by altering the volume of grease in the recoil cylinder.

### Improved Steering Features

The most important advantage of the independently driven tracks is in improved steering. The EUCLID TC-12 can be steered by :—

(1) Differentiating the individual engine throttles controlling each drive track.
(2) The application of the individual track brakes to either track
(3) Placing one transmission in neutral and using a track brake.
(4) Putting one track forward whilst reversing the other track.

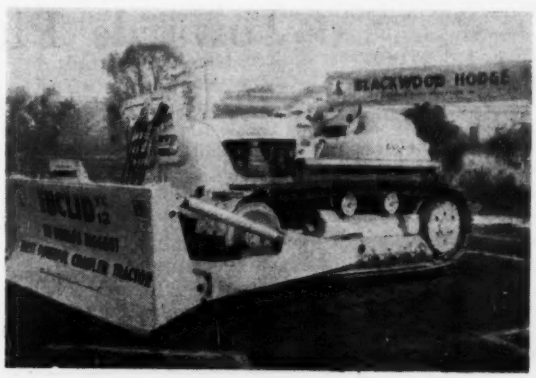
This flexibility permits turns ranging from even gradual arcs to tight pivot turns under full power.

### Transmission in one Compact Unit

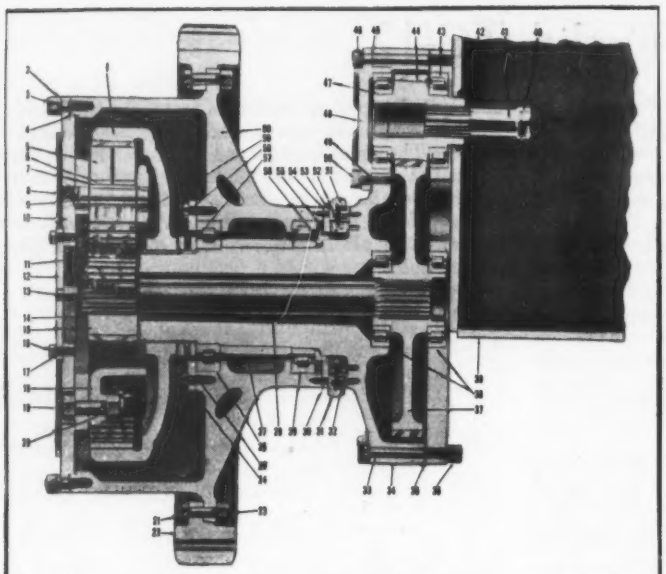
Each engine in the EUCLID twin powered crawler tractor is directly coupled to a transmission consisting of a torqmatic converter, a planetary hydraulically operated gear-box, and a reduction gear assembly, joined together to form one compact unit.

The torqmatic converter section in the transmission assembly performs two functions—it increases the torque or twisting force which the engine delivers, and acts as a fluid coupling between the engine and the planetary gear-box, when an increase or multiplication of torque is no longer necessary.

The planetary gear-box is of the consistent mesh type, whose purpose is to give the operator a selection of gear ratios or speeds to meet the various conditions encountered while the tractor is being operated. In addition, the forward or reverse direction of the tractor is controlled through the planetary gearing. This transmission requires no clutch or other mechanism to disengage the power whilst shifting from one gear range to another, or from a forward range to reverse.



**Final Drive**



1-Internal Gear
2-Lockwasher
3-Bolt
4-"O" Ring
5-Planet Pinion
6-Bushing
7-Washer
8-Plug
9-Pin
10-Driving Flange
11-Snap Ring
12-Plate Cover
13-Thrust Button
14-Snap Ring
15-Sun Pinion
16-Bolt
17-Lockwasher
18-Planetary Carrier
19-Bolt
20-Nut
21-Bolt
22-Drive Sprocket
23-Nut
24-Retainer Ring
25-Bolt
26-Bearing
27-Spacer
28-Drive Shaft
29-Bearing
30-Screw and Lockwasher
31-Outer Labyrinth
32-Screw and Lockwasher
33-Bolt
34-Gear Train Cover
35-Gasket
36-Nut and Lockwasher
37-Transfer Driven Gear
38-Bearing
39-Drive Case
40-Snap Ring
41-Quill Shaft
42-Oil Seal
43-Bearing
44-Drive Gear
45-Cover Gasket
46-Bolt and Lockwasher
47-Bearing
48-Cover Assembly
49-Stud
50-Nut and Lockwasher
51-Inner Labyrinth
52-Seal
53-Surface Plate Seal
54-Gasket
55-Snap Ring
56-Spacer
57-Lock Nut Assembly
58-Lockwire
59-Woodruff Key
60-Sprocket Hub

The planetary gear-box has three forward ranges (speeds) and three reverse ranges (speeds). The operator may select any range in either transmission independently and consequently this gives complete control over each track separately for fast, flexible steering and manoeuvrability.

The reduction gear section of the transmission assembly has two functions ; it affords a gear reduction and changes the direction of power from the gear-box, through ninety degrees to the quill shaft leading to the final drive unit. The individual multiple disc track brake assemblies are mounted on the outboard side of the reduction gear output shaft.

**Final Drive Assembly**

The final drive assembly used on the EUCLID Crawler Tractor is a full-floating, double reduction type. Full-floating means that the crawler drive sprocket is fully supported by two bearings mounted on the gear cover. This design prevents the final drive shaft from carrying any of the unit's weight.

The double reduction gearing multiples the torque delivered to the final drive by the transmission. The first reduction is accomplished by driving a large transfer gear with a small pinion which is splined to the transmission quill shaft.

The second or final gear reduction is in the planetary gearing, located in each drive sprocket hub. Thus, the final torque multiplication is completed at the ultimate point of power application which reduces the stress load on all power-train components.

**Ready Transportation**

The ease of separating the two halves of the EUCLID TC-12 for ready transportation has been a guiding factor in the development of this mammoth crawler tractor and the reassembly of the tractor presents no significant problems. The realignment of the two halves is the only critical requirement, and after this has been accomplished the re-assembly should require less time than the disassembly.

The EUCLID model TC-12 Tractor can be fitted with a double drum cable control unit and either a cable or hydraulically operated bulldozer/angledozer blade, or alternatively a push plate assembly.

Phone 445820

*To be published shortly*

**Towards Pluralist Society**

by

**K. K. SINHA**

Price—Rs. 8 ; $2, or 12 sh.

Publishers :—Writers' house

211, Park Street, Calcutta-17.

# Our Delhi Letter

*(From our own Correspondent)*

**Present Phase of Development—a Challange of India's Engineers**

A well attended meeting of the Institution of Engineers Delhi Centre took place on 8 February in which the representative engineers of the public and the private sectors got together. The subject of the talk was : "The Present Phase of Development : a challenge to Indian Engineers" by Mr C. L. Handa Director, Bhakra Dam Designs.

The points made related to the great part that engineers are called upon to play in the context of the country's critical requirements, for meeting the targets of the Second Five Year Plan Projects. In view of the fact that there was an increasing shortage of materials, man-power and foreign exchange, it was worth while for the engineers to reorientate their approach for overcoming difficulties and hurdles in order to maintain the programme and tempo of development works.

The first challenge was Organization. So far the country had been used to comparatively smaller achievement. In past methods, red tape and codal requirements constituted a big circumscription. Unless there is relaxation of the rules in an intelligent and practical manner, it will be difficult to keep pace with the programme. Engineers have therefore to bring in more or less *revolutionary* changes.

Only, this "revolution" would be in the minds and imagination and those ideas will have to be discarded which stand in the way of achieving the objective.

The next challenge is that of shortage of essential materials like steel and cement. Engineers, therefore, should collectively think in terms of minimising the use of these materials by suitable changes in designs. This is quite practicable in many instances as concrete can take place of steel. Also there is no reason why for less important structures the use of alternative material like timber, bamboo and sal ballies may not be made. In other countries there is much greater tendency in favour of local materials. In India, unfortunately the people have not got out of ruts and therefore every one demands those very materials which are in short supply. Also there are not enought facilities for research and confidence has not so far been generated in support of modified practices.

In the case of concrete the modern methods of batching and mixing by weight are capable of reducing cement without loss of strength. For all important and large structures it is necessary that the old practices for proportioning by volume be discontinued and new methods of weighment of materials to be introduced as is being done in the case of Bhakra Dam.

Examples were given by the speaker as to how economy in steel and cement can be effected. The working stress which is permitted in steel according to old practices is limited to 16,000 psi. Modern p actice permits this to be taken up to 20,000 psi.

For anything of this, however, the design has to be carefully checked. This all the design offices are not equipped to do, because of the shortage of personnel and absence of properly qualified men. But the resultant economy is big enough to justify the close attention that must be given to this aspect. The responsibilty for this belongs to the engineering profession. Implementation needs to be secured urgently.

Another instance in which steel can be saved is the adoption of modern welding methods in preference to the practice of providing lap joints in the steel reinforcement. It is well known that for the lap joints 40 times diameter has to be allowed. With welded joints this can be reduced to only a few inches, depending upon the diameter of the bars. A substantial economy is thus clearly indicated.

Referring to the economies in cement the speaker invited attention to the use of pozzolon in cement on on a larger scale. It is now established that from 1/6 to 1/5 of the cement content can certainly be replaced by pozzolon.

In the past pozzolon has been largely obtained out of burnt brick by powdering it to the required degree of fineness. It is now a well known fact that many shales constistute suitable raw material which by calcining can be converted into a proper material for grinding, into a pozzolon of the desired fineness. The cost of such a pozzolon is dependent on the scale, of and the purpose for which, it is intended to be used. By taking suitable precautions, it is possible to produce this pozzolon at a much smaller cost than cement. The pozzolon gives additional workability and impermeabilty to the concrete and therefore has a great technical advantage besides that of economy alone. In this present context of shortage of cement, the contemplated use of some 200,000 tons of pozzolon in Bhakra Dam alone is an example well worth attention.

This matter is urgent and needs the attention of high level engineers in the country. Priorities need to be determined and adhered to till the production of the required materials comes up to the mark. Otherwise the construction of vital projects is bound to be slowed down.

The next question is one of techniques. It is undeniable that Western countries have developed a lot of machines which help uniformity and speed of production. The good workman will certainly have a better out-put if his tools are improved. For this purpose the engineers ought to feel concerned. Time and motion studies are important to decide whether a particular equipment is efficient. Where large jobs are concerned repetitive movements of thousands of workmen are involved month after month and year

after year from project to project. The economy of the head basket with and without the wheel barrow, needs to be compared; Manual methods used by the workman in various countries of the East, including China, Japan and Indo-China should be thoroughly studied to work out the best hand tools. These do not involve any material expenditure of foreign exchange. In respect of the hand tools, which require the use of steel primarily, attention should be given to manufacture within the country and failing that importation from abroad. It is to be remembered that each modern efficient tool will add to economy in the execution of our projects.

### Respect for the Profession

The important item which surpasses all the others other in significance is the degree of respect which the engineering profession commands with reference to other sections of society. But their own conduct and earnest high level endeavour have to prove that their contribution to the country's welfare and production is too important to be slighted. The present time does not need so much of political ideology as greater production. This points out the important responsibility that has automatically fallen on the shoulders of the country's engineers.

Engineers should not forget that they also have their primary obligation to influence policies and decisions of Government. It is therefore necessary that they should oppose any project which, to their judgement, deserve lower priority than certain other projects which are capable of doing greater good to the country in the context of shortage of resources.

One finds that the engineers takes a secondary role due to his self-imposed inferiority complex. He therefore has the unfortunate task of complaining that the Administration and Finance Authorities fo not give hin full cooperation. It would be more appropriate if by there own earnest work in investigations, planning, and implementation of projects, engineers make it more or less clear to the Administrators and Financiers, that it would conduce much more to the country's progress if the engineers were given fuller initiative, which would be of effective help for the furtherance of projects which are entrusted to his charge. Thus, vital effort will be conserved for promoting direct constructive activities which are so necessary, for the achievement of the targets set forth in the Country's 5 Year Plans.

### Revolution in Engineering Ideology

Mr F. C. Budhwar, while winding up the the dicussion on as President remarked that a democratic revolution in the country's engineering field was taking birth with the ideology which had been lucidly presented by the speaker and participated in by the audience. It was a type of heart warming discussion which has a definite place in the up-surge of economic development.

### Water Resources Development Centre, Roorkee

Attention of the profession needs to be drawn to the the progress that has been made in the Water Resources Development Trainees Centre at the University of Roorkee. At the conclusion of the First Year's course, the trainees at Roorkee with their studies at the university and training at the sites of works in the various Projects, will apply their knowledge to the solution of the project papers.

The Teaching staff at this Centre has been greatly augmented by the posting of some India's senior engineers and also of some emminent foreign experts. Shri A. N. Khosla, Vice Chancellor of Roorkee University, has by his personality and example infused a dynamic spirit of progress in every sphere. It is appropriate that the country should make extended use of this Centre.

### Optimum pace of achievement

Time has come when a careful review must be made for the optimum pace at which construction should progress. It is not enough at this stage to have cheap satisfaction by the adoption of leisurely programmes and retarding the pace of development. On the other hand we should make the fullest use of our equipment and investment to be able to earn returns and advance benefits. Only then will the low standards of our people be raised within reasonable time, thus saving us from frustration of too long a waiting period.

How can this be done ? What steps should be taken to assist our projects in a real reliable way so that we know where the bottle-necks are and how with better planning and better coordination we can achieve more results with the same effort ? This requires the coordination of various operations and telescoping of our resources in men, machinery and material. The cooperation of the concerned agencies must be forthcoming in an enthusiastic manner so that suggestions have not to be imposed from without, but are accepted with voluntary enthusiasm. This suggestion has been implemented to some extent by the Committee of Plan Projects formulating their economy and efficiency units, through which they are exploring ways and means for expediting the programmes and reducing the gap between generation and utilization, both in the Power and Irrigation aspects, the objective to be achieved by conferences between senior engineers attached to the Planning Commission and those in charge of execution of the projects. The advantage of such an arrangement is that instead of the post mortems, timely suggestions are made for the improvement and modification of the works on the basis of agreed designs. As each work has its own problems, and its own solution, this procedure is expected to produce better confidence. Besides, the authorities in charge of the works will get a further opportunity to represent their views during the course of joint site inspections and discussions.

### Team for Irrigation and Power Projects

It is learnt that in the case of Chambal and Lakkavalli projects, a Chief Engineers' Team has been constituted. The personnel of this team are C.L. Handa, Director, Bhakra Dam Designs, G.H. Pandit, Superintending Engineer Bombay and M. Narasimhaiya, Retd. Chief Engineer, Mysore State. They are to report to the Committee on Plan Projects through Shri N. V. Gadgil who has been designated Leader of the Team. There will be a Consultative Committee comprising of Shri A. N. Khosla, Shri Thirumale Iyengar, Shri R. K. Gupta and Shri N. N. Iyengar—all engineers of repute who have won the country's confidence in their long careers. Shri Kanwar Sain, Chairman C.W.P.C., will still be the Consulting Engineer to Government and will be associated in his capacity as such.

# Need for an Indian Economic Service

Sri Kanwar Sain's Presidential Address at the Annual General Meeting of the Institution of Engineers (India) this year (extracts of which have been published elsewhere in this issue) have been inspired with some courageous thoughts and fervent idealism and needs to be taken notice of not only by the engineering profession but also by our political and administrative leadership. Specially towards the end of his address he reflects a mood and an attitude of mind which gives the impression, however vaguely, that the engineering community feels a sense of injury arising out of inadequate recognition of its status that it thinks it deserves in society and in the hierarchy of the institutional framework. Coming as it does from a person who not only speaks in the name of those engineers who are in government service but also outside it, it signifies the unexpressed thoughts of a section of our society on whose shoulders depend to a large extent the success of the Second Plan. Be it noted, this is not a new or unexpected expression of their mood ; if one goes through the speeches of the senior engineers on all such and similar occasions for the last three or four years, one will notice that this sentiment has been brewing up for quite sometime. It is time that serious notice was taken of this trend of opinion among engineers ; for if it continues, it will be neither good for the country nor for the engineers.

The sum and substance of the engineers' point of view consists in this that they should be an integral part of the administrative setup at the highest level, so that they can share both in policy-making as well as in administration of departments and projects and subjects which require technical engineering knowledge. We hope we are generally correct in our above formulation. Two particular aspects of this issue have been referred to on several occasions in this connection. One is the constitution of an all-India service of engineers ; and the other of engineers becoming Secretaries of Departments that mostly concern engineering work.

In this connection one has to think of still broader questions of administration involved. As the country is intensifying its dynamics of economic development in terms of the five-year plans, it is faced with administrative problems of which it had no comparable experience before. India for the last one hundred years was mainly concerned with *political* administration. But now, in addition to this, it is faced with administration of the economic sphere of the community as well as of the educational. And because it has accepted a socialist and a welfare outlook under which State undertakes direct control of all these spheres of life, the problems of administration become almost overwhelming in character.

With the rapid pace of industrialisation and resource development, innumerable large-size economic units are cropping up that need to be competently run and administered. In the midst of this growing compexity, it appears, the leadership of the ship of State seems to be caught unawares and even intellectually unprepared. The economy is expanding like the Alladin's *gin* on all sides, but there appears little evidence of an integral approach by which these rising *gins* could be controlled and guided. To our mind it seems that a new philosophy of social administration is needed.

It is in this context that we have to view the problems and issues raised by Sri Kanwar Sain. It is quite natural that in the absence of a general framework of reference new forces are emerging from within the growing economic pattern that are urging for recognition. Engineers are one such. There are a number of others. The old and established framework of the ICS and the IPS are holding fast against this rising pressure. But the enlarging economic sphere is bound to exercise a subterranean upward force that can hardly be resisted. The demand of the engineers is an indication of this trend. It reflects the emergence of the new forces and, therefore, should be sympathetically understood. On the other hand, left to itself it may deflect into a trade-unionist bias and thus become a source of vested interest for its own sake, encouraging a multiplication of such tendencies in other specialist groups. That will be sowing a seed of disruption from within as it were. It was good that Sri Kanwar Sain strongly argued against this trend towards unionism. But how long this persuasion can hold out ?

The problem is not a choice between the "generalists" and the "specialists." We need both. The classifications should, however, be different. We already have a sufficiently experienced cadre of political administrators but not those of the economic and the educational. All these three spheres require their respective but different service cadres. Thus if there be developed an Indian Economic Service, it could be trained to take charge of the developing economic units. Within this service we could have sub-divisions of a *loose* and flexible kind consisting of an engineering group, finance and accounts group, chemical group, administrative group, etc. The idea underlying it is that economic development is a programme which is now specialised enough to be detached from the general administrative structure and developed into a Service of its own and the subgroups are really specialised parts of the whole apparatus for economic development.

If this principle is accepted, it will imply a breaking up of the present ICS and IAS group into two or three wings, each member of it being allotted the wing to which he is more suited by aptitude and record. This will also mean the absorption of engineer-administrators into the new Service where each of them can compete with the rest on merit, both specialist as well as generalist, and take his due place in the task of shaping the economic future of the country.

May we humbly submit this approach to the consideration of our leaders and administrators.

*Continued from page* 26

## All India Power Engineer's Conference Bangalore 1957

the considered view of this Conference that impulse tests of transformers should be restricted to the type test and not a routine test. The insulation levels to be specified by the States should conform to the revised B.S.S. 171 and the ISI Standards that may be issued from time to time.

*Resolution No.* 15

### Foreign Exchange

This Conference views with great concern the shortage of foreign exchange indicated by the several circulars which the State Governments have recently received from the Ministries of Finance, and Irrigation and Power, and the Central Water & Power Commission in this behalf. While it recognises the need to conserve foreign exchange and carry the appropriate share of the burden of the general shortage of foreign exchange experienced by the country, it wishes to forcefully bring to the notice of the authorities concerned that electric supply industry is essential to the general economic uplift of the country. The accomplishment of the industrial and major portion of railway expansion programmes of the Second Five Year Plan is to a large extent dependant upon an adequate supply of electric power being made available throughout the country. Electric supply being the fore-runner of the expansions referred to above, it should be given due consideration in the allocation of the available foreign exchange.

Many projects undertaken during the Second Five Year Plan and continuing from the First Plan have ordered only a portion of the equipments such as generating units, step-up transformers ; switchgear, transmission line equipment, grid substation equipment are yet to be ordered for completing the equipment required for the benefits of these projects being made available to the consumers. Unless adequate foreign exchange is made available for the above purposes, the amount already spent and to be paid for on orders already placed, would become an unremunerative outlay until the projects are completed and serviced for the benefit of the people of the country. It is, therefore, apparent that somehow or other the required foreign exchange should be made available to complete the projects already commenced and for taking up the projects where great shortage of power is experienced.

*Resolution No.* 16

### Railway Crossings

This Conference views with concern the prolonged delays reported by the various power supply authorities in obtaining approval of the Indian Railways for transmission line crossings. The Central Water & Power Commission in collaboration with the Railway Board have evolved standard forms of transmission line crossings which are contained in the "Revised Regulations governing the placing of transmission lines across railways" issued by the Railway Board. The power supply authorities are invariably adopting these standards. Therefore it appears that the delay reported is a procedural one and could be minimised as far as practicable. Hence, the Conference requests the Central Water & Power Commission to take up the question with the Railway Board and arrange for simplification of the procedure in obtaining approval for the railway crossings

---

**Indian Journal of Power & River Valley Development**

REGISTRATION OF NEWSPAPERS (CENTRAL) RULES, 1956:
FORM IV (RULE 8)

| | | |
|---|---|---|
| 1. | Place of Publication | .. 6/2, Madan Street, Calcutta-13. |
| 2. | Periodicity of its publication | .. Every month |
| 3. | Printer's Name | .. P. K. Menon |
| | Nationality | .. Indian |
| | Address | .. 6/2, Madan Street, Calcutta-13, |
| 4. | Publisher's Name | .. P. K. Menon |
| | Nationality | .. Indian |
| | Address | .. 6/2, Madan Street, Calcutta-13. |
| 5. | Editor's Name | .. K. K. Sinha |
| | Nationality | .. Indian |
| | Address | .. 211, Park Street, Calcutta-17. |
| 6. | Name and address of individuals who own the newspaper and partner or shareholders holding more than one per cent of the total capital | P. K. Menon .. 6/2, Madan Street, Calcutta-13. |

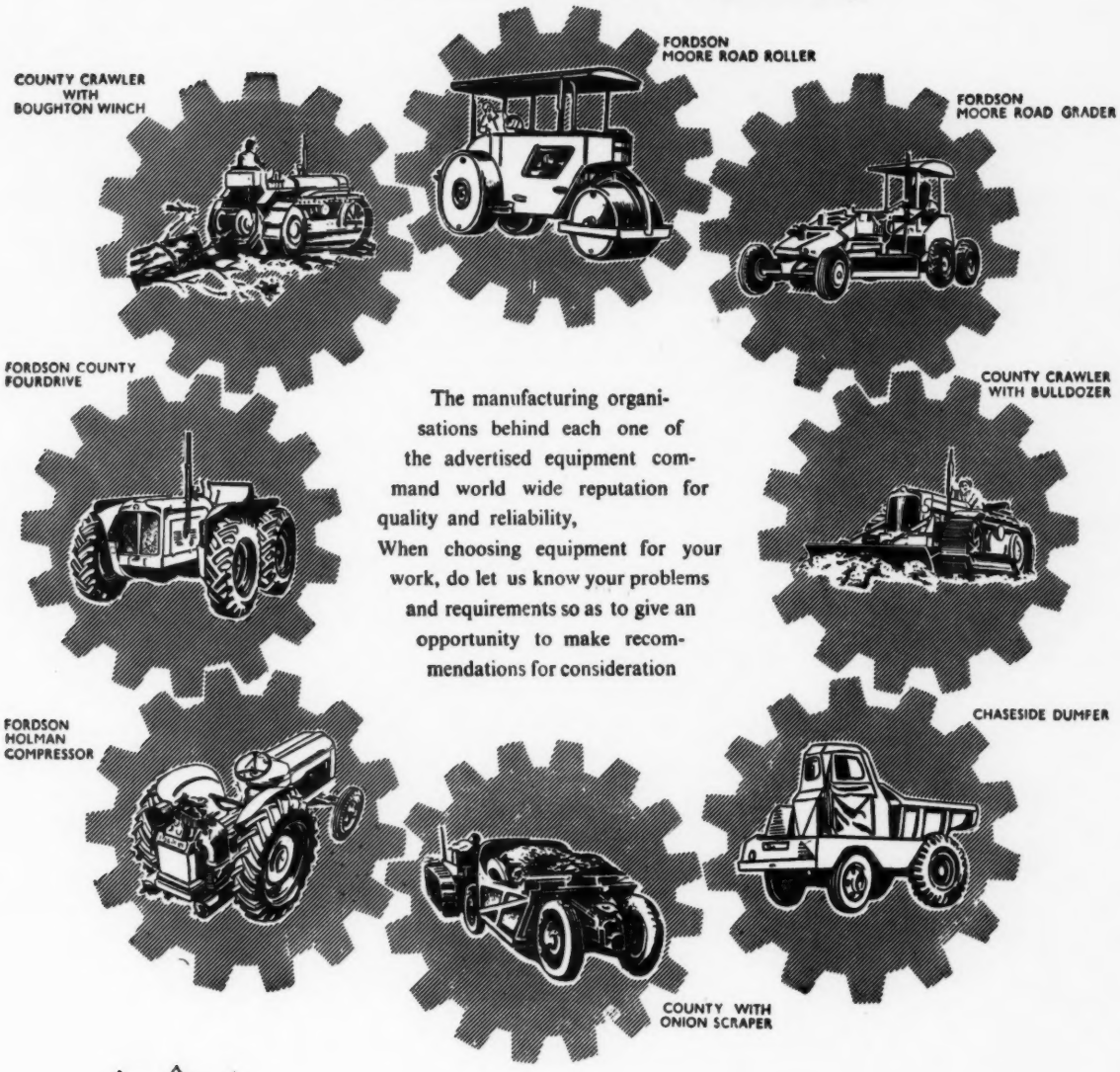
I. P. K. Menon, hereby declare that the particulars given above are true to the best of my knowledge and belief.

*Date*, 1-3-57.

Sd./- P. K. Menon,
Signature of Publisher.

---

# *Famous Names Geared To India's Prosperity*




The manufacturing organisations behind each one of the advertised equipment command world wide reputation for quality and reliability,
When choosing equipment for your work, do let us know your problems and requirements so as to give an opportunity to make recommendations for consideration

U.P.C.C
EVERYTHING FOR THE FARM

ASSEMBLERS & SOLE DISTRIBUTORS IN INDIA

**THE UNITED PROVINCES COMMERCIAL CORPORATION**

**6, GANESH CHANDRA AVENUE, CALCUTTA**
**Post Box No. 2491**

P.P.S./PS 2856

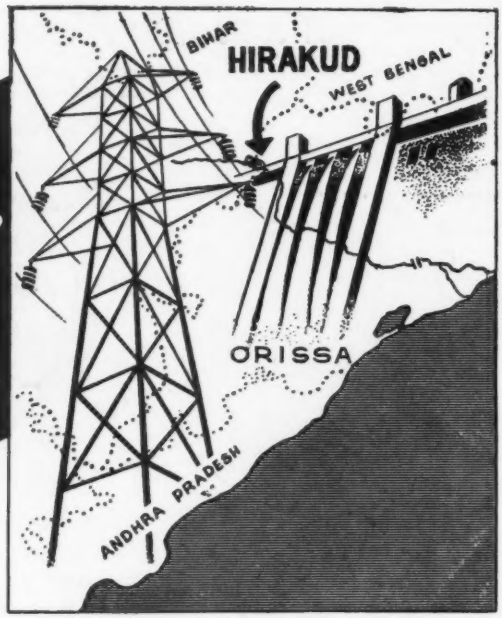


Printed and published by P. K. Menon from Inland Printing Works, 60-3 Dharamtala Street, Calcutta-13
Editorial & Managerial Office : 6/2 Madan Street, Calcutta 13

Regd. No. C 3873


# HIRAKUD...

## and there we are!




THE Hirakud Multi-purpose Project marks yet another milestone in the country's onward march of progress.

The first controlled flow of irrigation waters from the Hirakud reservoir will start the growing of additional crops; and the first flow of electricity along new transmission lines will help in the building of new industries.

A richer life for the people of Orissa will be the welcome result.

AL-IND

**THE ALUMINIUM INDUSTRIES LTD.**

*India's largest manufacturers of Aluminium Cables and Accessories*

**KUNDARA KERALA STATE**

*Managing Agents:* **SESHASAYEE BROS. (TRAV.) PRIVATE LTD.**

We propose installing new facilities — both rod and cable — at Hirakud. Construction work has already been taken in hand.

AL-361